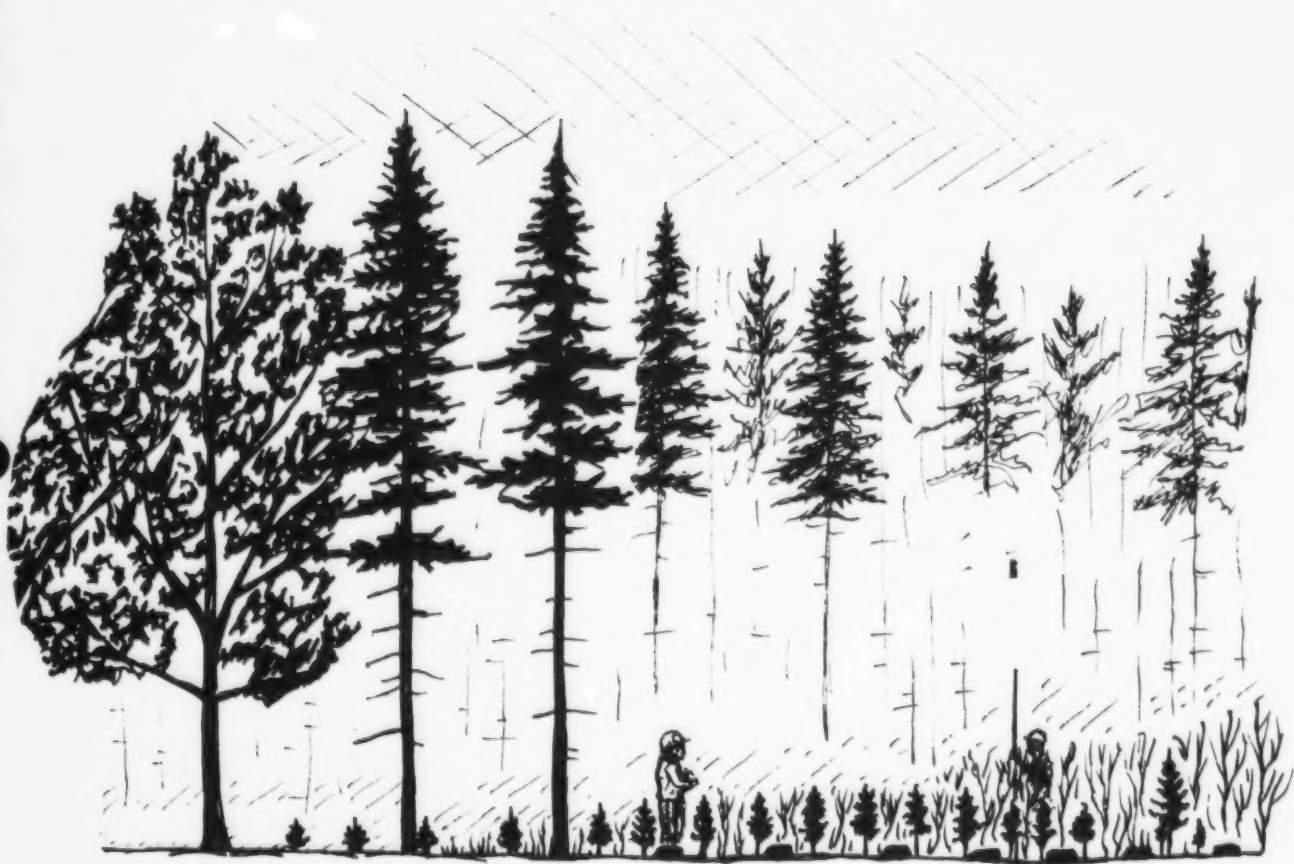


WOODLOT MANAGEMENT HOME STUDY COURSE



MODULE 5 STAND ESTABLISHMENT

This module on Stand Establishment is divided into three lessons:

LESSON ONE: Introduction to Forest Stand Establishment

LESSON TWO: Natural Regeneration Management

LESSON THREE: Artificial Regeneration Management

These lessons contain a True or False Quiz to test your understanding of the material. A woodlot management exercise is also provided to apply some of the useful knowledge given in this module.

This Module is the fifth in a series of
Woodlot Management Home Study Courses
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LESSON ONE

INTRODUCTION TO FOREST STAND ESTABLISHMENT

Forest stand establishment is a practice that ensures new healthy seedlings replace mature and overmature stands of trees as they are harvested. This Home Study Module will discuss how natural and artificial regeneration techniques can maintain or improve the productivity of our woodlots by ensuring good stocking levels after harvest.

Successful stand establishment is the most important step toward good forest management. Without new seedlings, the site may not realize its full productive potential. It is similar to the carrot patch that has poor seed germination and produces more weeds than carrots; the garden is simply not as productive as it could be.

STOCKING

Stocking is the term used to describe whether there are enough trees per area and is usually expressed as a percentage. To better understand stocking, consider forest sites and stands as graphically comprised of square plots (Figure 1).

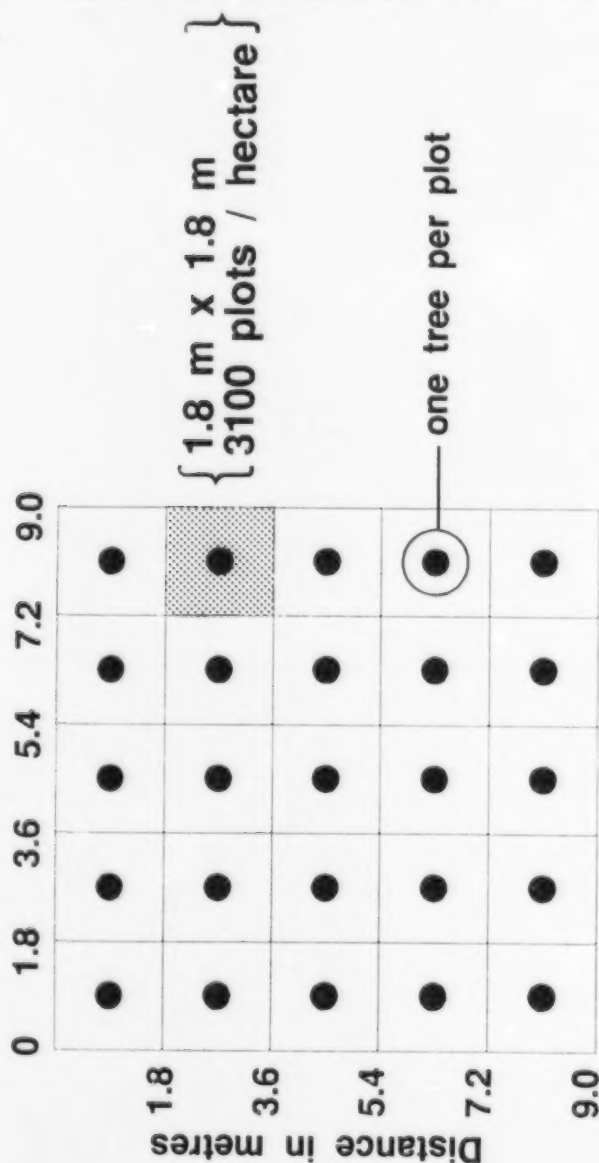
In Nova Scotia we usually plant seedlings and precommercially thin young stands to a spacing of approximately 1.8 - 2.4 metres (6 - 8 feet) between stems. Forest research indicates that these spacings are best for early tree growth and development for our average sites, tree species, and climate. Ideal spacing is 1.8 m x 1.8 m (6' x 6'), aiming for approximately 3,100 trees/hectare (1,210 trees/acre). This spacing provides young stands with 100 percent stocking and a good chance for survival during its first 40 years (Figure 1). At narrower spacings, the trees have inadequate space and slow diameter growth. At wider spacings, trees have too much space and will become limby and have less useable wood.

Each tree will develop and grow best if it is sufficiently free of competition from weeds and other trees for light, moisture and nutrients. When trees are taller than the competition, they are considered "free growing".

For plantations or naturally regenerated stands between one and 40 years of age, all plots must have one healthy, free growing

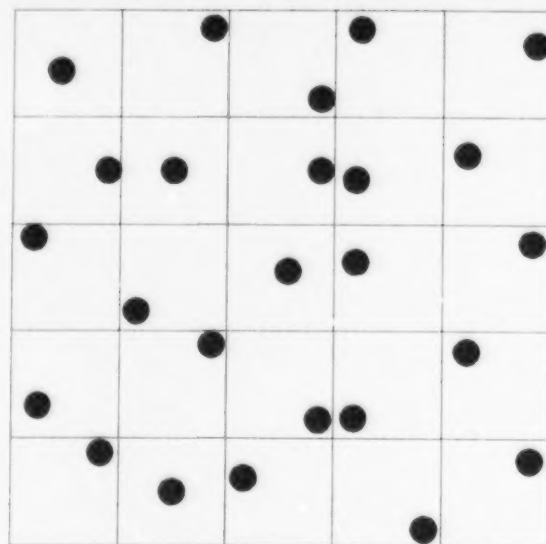
FIGURE 1. GRAPHIC VIEW OF FOREST PLANTATIONS AND YOUNG STANDS

PLANTATION



NATURAL STAND

(PRECOMMERCIALY THINNED)



Distribution not as even
but production similar
if all plots occupied

tree for the site to be fully stocked (100%). A fully stocked area is fully utilized by growing as much wood as possible of a commercial tree species.

On the other hand, the site is only partially stocked if some plots are either barren or occupied by non-commercial species. Usually, partially stocked sites are expressed as a percentage. For example, if 1550 of the possible 3,100 plots/ha are occupied by commercial species, the site is 50% stocked and is only growing approximately 50% as much wood as possible.

However, openings on a woodlot may be desirable for wildlife. These areas will be used by many different species for feeding, hunting, and courting. Wildlife and forestry is the topic of Home Study Course Module IV.

In Nova Scotia, average sites with fully stocked stands can produce approximately one cord per acre per year for softwood species such as red spruce, balsam fir, and white spruce. Therefore, the softwood plantation or natural stand in Figure 1 should contain approximately 358 cubic metres/ha (40 cords/ac.) at 40 years. Hardwood trees produce less volume and generally fewer trees per acre than softwoods in a fully stocked stand because of the larger crown development. Softwoods have a more compact crown and use less energy to produce new needles annually.

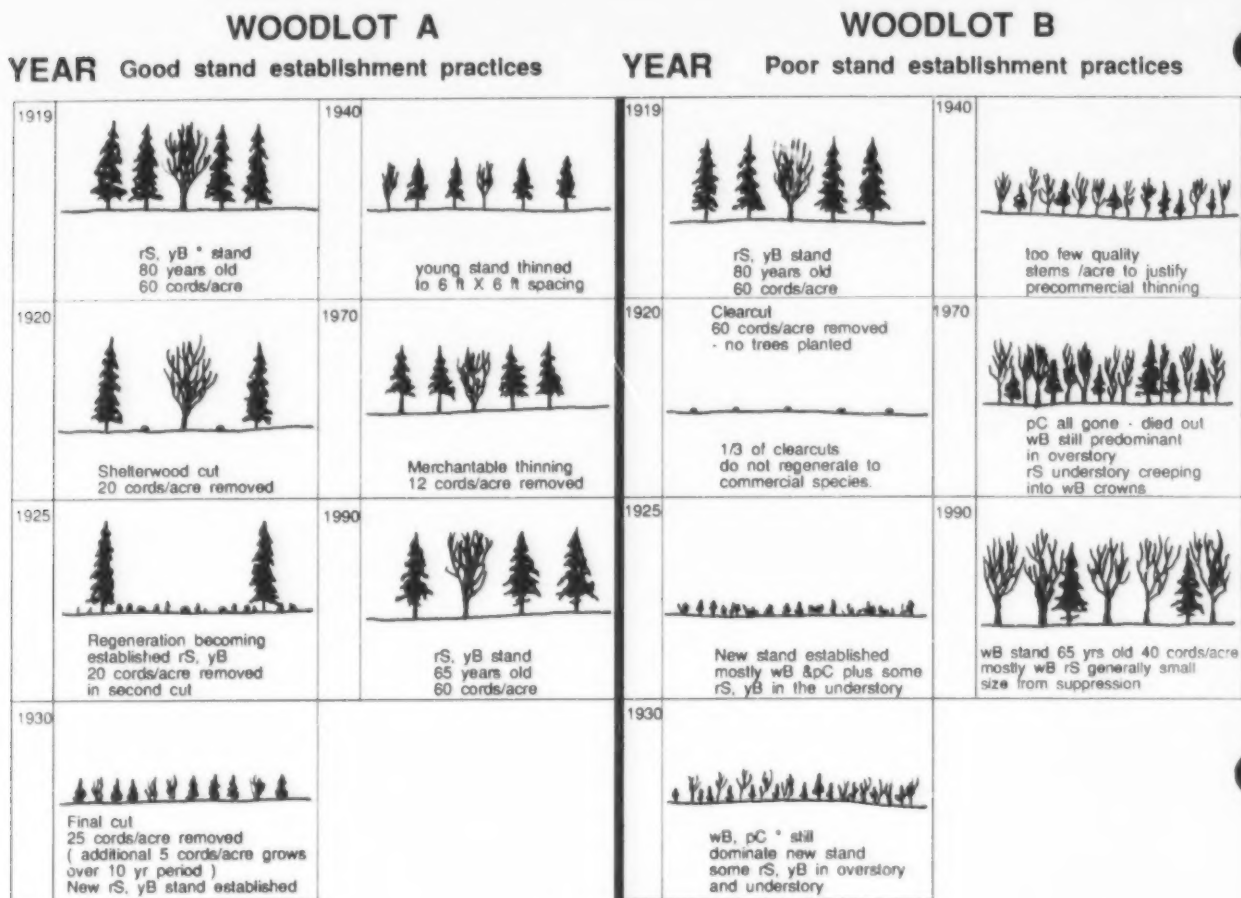
It is important to understand stocking, site utilization, and the potential of sites to grow wood since these factors influence the establishment practices on our woodlots.

Cutting the forest without thinking about the next generation of trees can reduce the quality of the next stand. This cutting practice can develop into highgrading which removes the biggest and best trees and leaves poor quality trees to produce seeds. Highgrading is evident in all regions of Nova Scotia where there are now some stands of poor quality hardwood and softwood growing on sites previously occupied by more valuable species (Figure 2).

Nova Scotia has approximately 30 native tree species. Ten of these will not be discussed because they are not common. Of the remaining 20 species, four have little commercial value, but play an important role in forest development and succession. They are striped maple, pin cherry, grey birch, and speckled alder.

Sixteen commercial species are listed in Figure 3, along with their relative percentages of total growing stock. Total growing stock is an estimate of the total standing wood volume in Nova Scotia. In 1987, this volume was estimated at 406 million cubic metres (112.3 million cords).

FIGURE 2. COMPARISON OF FOREST SITE PRODUCTION BETWEEN WOODLOT A AND WOODLOT B



EPILOGUE

**77 cords/acre
production since 1919,
mostly good quality rS yB.**

**Good utilization of site
potential by insuring
adequate regeneration.**

Approximate value (1990 prices)
 70 % sawlogs = 24 Mfbm/acre
 @ \$175/Mfbm = \$4200.⁰⁰
 30 % pulpwood = 23 cord/acre
 and fuelwood
 @ \$ 50/cord = \$1150.⁰⁰

**Total approximate
roadside value = \$5350.⁰⁰**

**40 cords/acre
total production since
1919, mostly wB**

**Poor utilization of
site mostly as low
grade hardwood**

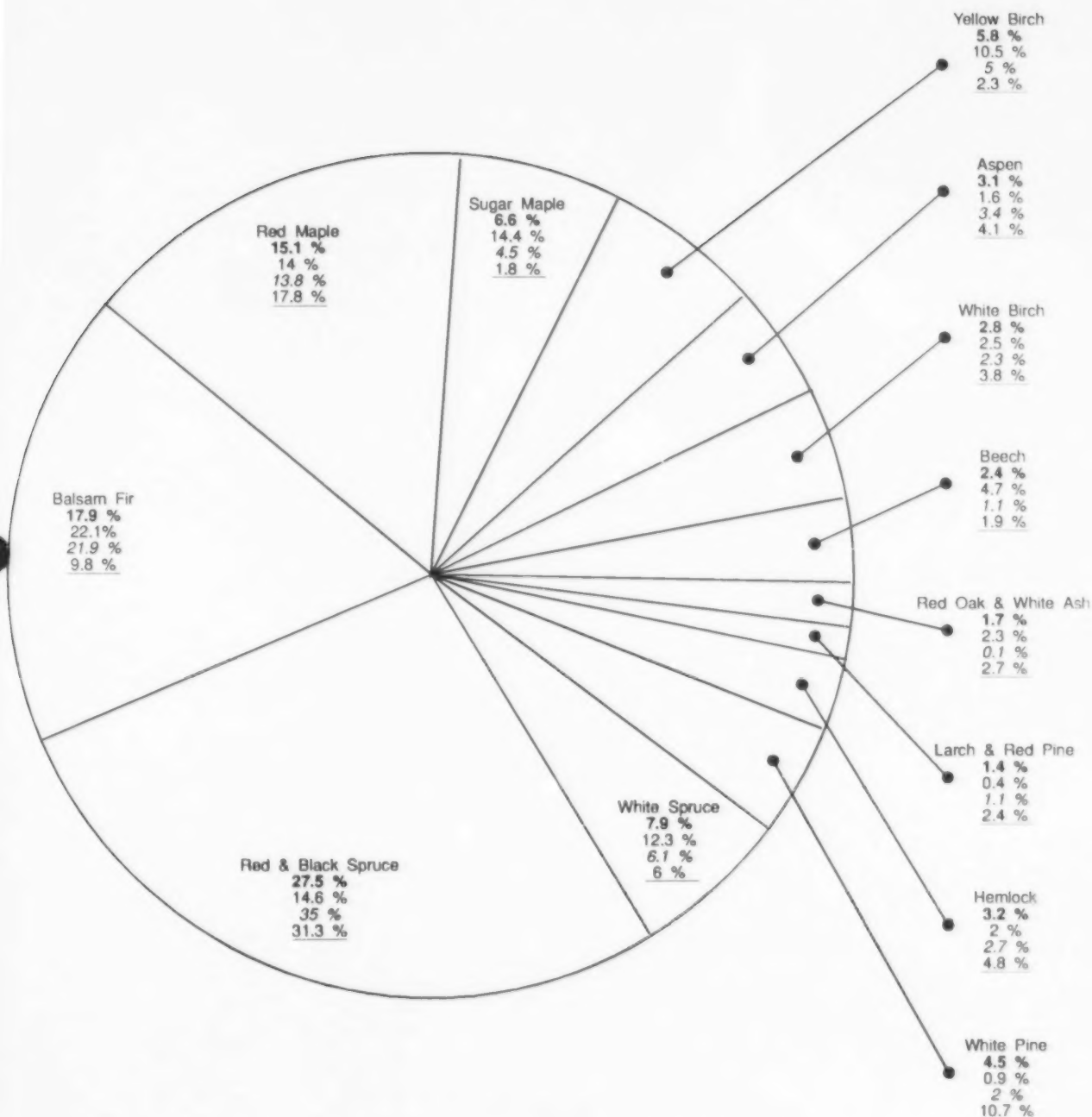
Approximate value (1990 prices)
 NO sawlogs

**40 cords pulpwood and
fuelwood @ \$ 50/cord = \$ 2000.⁰⁰**

**Total approximate
roadside value = \$2000.⁰⁰**

* rS = Red Spruce, yB = Yellow Birch, pC = Pin Cherry wB = White Birch.

**FIGURE 3 TOTAL GROWING STOCK PERCENTAGES FOR
THE MOST COMMON TREES OF NOVA SCOTIA
(1987 PROVINCIAL INVENTORY)**



EXAMPLE ; Species **Red Maple**
 Provincial Average **15.1 %**
 Eastern Region **14 %**
 Central Region **13.8 %**
 Western Region **17.8 %**

FOREST SUCCESSION

Have you ever wondered why one or several tree species occupy much of your woodlot? The answer may simply be that these trees are best suited and compete well in that particular woodlot environment. When discussing the environment of your woodlot, consider the climate, soils, topography, and site history. Together, these factors help determine the types of trees that grow on your woodlot.

Climate:

Is it hot or cold, wet or dry? As a very general example, Cape Breton Island and the Eastern Shore have hardy species such as balsam fir and black spruce because of a cool, damp climate and short growing season. Western Nova Scotia has a drier, warmer climate and a longer growing season which may favour red spruce, red oak, or white pine. The abundance of all native species varies throughout the province.

Soils:

Is the soil rocky? Does it contain well drained sandy loams or poorly drained clays, etc.? Pines regenerate, survive, and grow better on dry sites because they have a deeper rooting system than most conifers. They are commonly found on the dry, sandy loam soils of western Nova Scotia. Black spruce and larch can withstand excessive soil moisture better than other species and are found on many swampy areas throughout Nova Scotia. Black spruce and larch are also found on the better sites, but usually don't compete well with other species.

Topography:

Is your woodlot on a mountain top, close to a windswept seashore, or in a valley? Hardwoods are more likely to be found on ridges and hillsides, while softwoods are more likely to dominate valleys. Forests near shorelines of are dominated by white spruce because they are able to withstand damage caused by wind and salt spray.

Site History:

Has your woodlot been burned, cut, farmed, or has it been undisturbed for the last 200 years? This history is often the major factor that relates to the present species and stand type. For example, white spruce regenerates quickly on abandoned fields and pastures throughout Nova Scotia, usually forming pure stands. It regenerates better than all other 19 tree species with grass on old fields or pastures. There is close to one million acres of white spruce on abandoned farmland in our province.

Most woodlots are usually made up of several stand types with various species and ages. Since artificial regeneration is a relatively new management tool in Nova Scotia, most stand types

have become established from natural regeneration. These stands became established because the particular site history that existed favoured the development of certain species. In many areas you can stand on the boundary line separating two woodlots and see stands of completely different species composition; one side of the line can be 100% softwood and the other side 100% hardwood. The climate, soils, and topography on both sides of the line may be similar, but the site history has obviously been different.

Forest succession is the change in species composition, over time, as long-lived climax species replace short-lived pioneer species. There are several successional patterns in the forests of Nova Scotia. One example commonly found in the western area is shown in Figure 4.

In Nova Scotia there are many climax forest types made up of pure or mixed stands. Balsam fir dominates the climax forest types on the plateau of Cape Breton Island while red spruce dominates the climax forest types of mainland Nova Scotia.

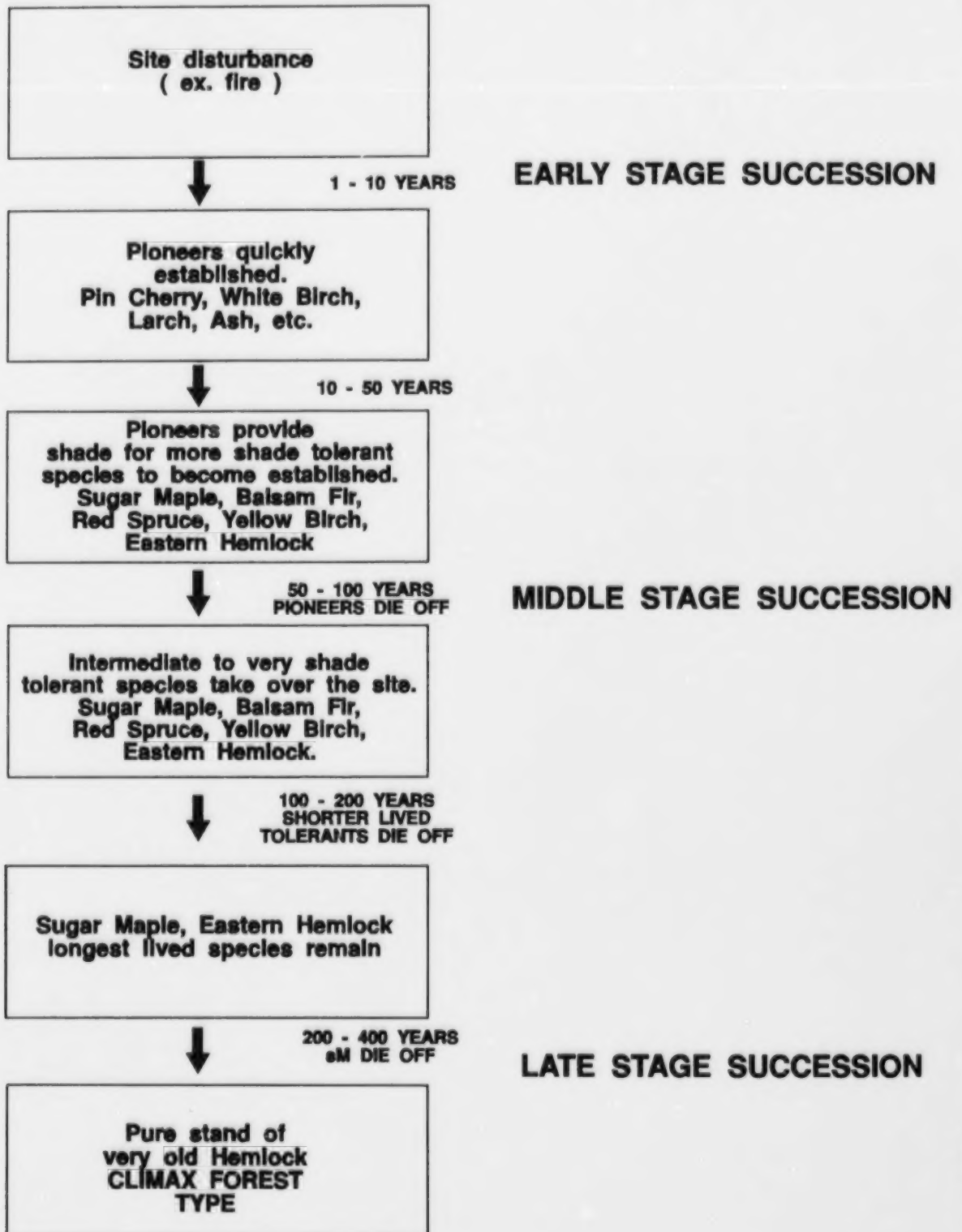
The introduction of beech bark canker in the early 1900's has removed beech from the climax position that it once held. Sugar maple and yellow birch now occupy a climax position in our forests.

To help understand forest succession and why forests often change species after disturbance, 20 tree species are grouped into five classes, based on their ability to survive and grow in shaded conditions, known as shade tolerance (Table 1). It is important to understand shade tolerance to understand where each species fits into forest succession. You will then begin to understand why your woodlot reacts and develops as it does over time. Please study Table 1 carefully.

The following is an example of how the shade intolerant-tolerant relationship works with natural succession.

In a two-story stand, shade intolerant species usually overtop the shade tolerant ones. On your next walk in your woodlot, compare the trees in the top canopy of a two-story stand to those in the bottom. You will generally find intolerant species such as aspen, white birch, or larch above balsam fir or red spruce. You will never find aspen, white birch, or larch growing under other trees.

**Figure 4. SAMPLE OF FOREST SUCCESSION
FOUND IN NOVA SCOTIA**



**TABLE 1. SHADE TOLERANCE AND THEIR
RELATIONSHIP TO FOREST SUCCESSION**

A. VERY INTOLERANT TO SHADE	B. INTOLERANT TO SHADE	C. INTERMEDIATE TOLERANCE TO SHADE	D. TOLERANT TO SHADE	E. VERY TOLERANT TO SHADE
White birch Aspen / Poplar Tamarack (Larch) Pin cherry Grey birch Alder	Red pine	Red maple White pine White ash Red oak	Red spruce Black spruce White spruce Yellow birch Striped maple	Balsam fir Sugar maple Hemlock Beech

EARLY STAGE SUCCESSION	MIDDLE STAGE SUCCESSION	LATE STAGE SUCCESSION
<p>Generally shorter lived</p> <p>Light loving species</p> <p>Seeds require heat or full sunlight at least part of the day to germinate and grow.</p> <p>Fast growing, straight trees in well stocked stands (lower branches quickly die under shaded conditions)</p> <p>Lower wood production/acre under full stocking because of lower live crown depth than more shade tolerant species (Figure 5.)</p> <p>Generally prolific seeders</p> <p>Seeds light/small easily dispersed great distances by wind.</p> <p>Some of these species use stump sprouting/root suckering abilities to quickly establish/ occupy cutover sites.</p> <p>These pioneer species best suited to clearcutting and modified clearcuts (strips, patches)</p>		<p>Generally longer lived</p> <p>Seeds will germinate and grow under very shaded conditions (100 %)</p> <p>Require partial sunlight for best seedling survival and early development (30 - 50 % crown openings for 5 - 10 years best.</p> <p>Slower growing than intolerants (pioneers)</p> <p>Lower branches retained for longer periods of shading ...trees generally do not self prune as well as intolerants.</p> <p>Generally more valuable species for wood products</p> <p>These climax species generally best suited to shelterwood or selection cutting.</p>

Figure 5 illustrates this situation and gives some of the reasons why shade intolerant species usually become established before shade tolerant ones.

Using the shade tolerance ratings in Table 1, our potentially most valuable trees occupy the middle to late stages of succession.

- * intermediate species - white pine, white ash, red oak
- * tolerant species - red spruce, black spruce, white spruce, yellow birch
- * very tolerant species - sugar maple

On the other hand, our least valuable trees for forest fibre products dominate the early stages of succession.

- * intolerant species - white birch, aspen, larch, pin cherry, grey birch, alder

This explains why our forest management programs modify, as much as possible, the earliest stages of succession. This is accomplished by using either natural or artificial regeneration management techniques.

Forest management programs aim to produce healthy, productive forests capable of yielding increased volumes of high quality products. Consideration is also given to the maintenance or enhancement of fish and wildlife habitats, water quality, and recreational opportunities.

STAND ESTABLISHMENT IN NOVA SCOTIA

The main priority of our stand establishment practices is to ensure that the percentage of high value species is maintained or increased on our woodlots. In 1987, approximately 54 percent of our forest growing stock was made up of our most desirable species (Table 2).

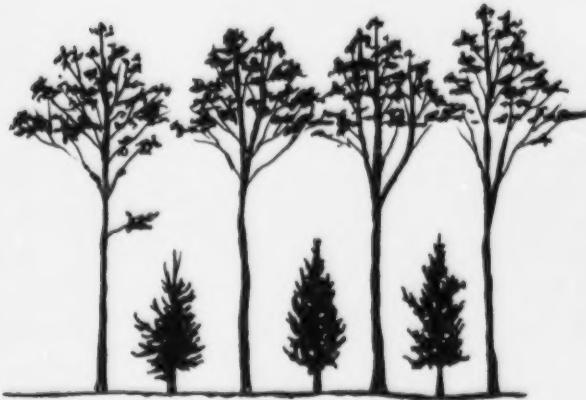
From a stand establishment perspective, where do you begin? Start first by examining your land to see what is there. Does your woodlot have the following:

- (1) old stands
- (2) poorly stocked stands
- (3) young, immature stands with species of very low value

If your woodlot has these types of stands, you may want to consider stand establishment techniques to improve productivity. The easiest way to get started may be to get help from forestry personnel from the Department Natural Resources, a Forest Group Venture in your area, or an approved forestry consultant. They can help develop a management plan for your woodlot. The plan will identify similar stand types and provide information on species composition, tree heights, ages, percent stocking, wood volume per area, stand condition, maturity, and regeneration stocking by species.

FIGURE 5. EARLY STAND DEVELOPMENT OF SHADE INTOLERANT VERSUS SHADE TOLERANT SPECIES.

Very intolerant to shade



40 Years old (6'x 6' spacing)

Intolerants such as Larch or Aspen generally grow more quickly in height during early stages than tolerants

Open crowns of intolerants enable partial sunlight to reach the forest floor which enables establishment of more shade tolerant species like Red Spruce and Balsam Fir.

Shaded leaves quickly die thus leaving a straighter better pruned stem than shade tolerants.

Shade intolerants are generally shortlived and after 50 to 80 years stands will die and allow the shade tolerant species to take over the site.

Very tolerant to shade



40 Years old (6'x 6' spacing)

Shade tolerants such as Sugar Maple and Hemlock have dense compact crowns with many leaves growing in shaded conditions. Thus tolerants are more limby than intolerants under similar stand densities.

The forest floor is very shaded compared to intolerant stands. Seeds from tolerant species may germinate but usually don't get enough light to survive.

Tolerants are generally long-lived and may survive for 100 - 200 years. Natural thinning will occur with some trees but neighbouring healthy trees will quickly fill in any opening.

**TABLE 2. MANAGEMENT PRIORITY OF NOVA SCOTIA
BASED ON POTENTIAL ECONOMIC
VALUE AND THEIR PERCENTAGE OF GROWING STOCK**

	SOFTWOODS	% OF GROWING STOCK		HARDWOODS	% OF GROWING STOCK	
		1984	1987		1984	1987
HIGHEST PRIORITY	White Pine Red Spruce Black Spruce White Spruce *Norway Spruce	39 %	40 %	Red Oak Sugar Maple Yellow Birch White Ash	12 %	14. %
LOWER PRIORITY	**Balsam Fir Larch Hemlock Red Pine	30 %	23 %	Red Maple White Birch Beech Aspen	19 %	23. %

* Norway Spruce, an introduced species from Europe, is generally doing very well in Nova Scotia and it is a frequently requested species for planting.

** Balsam Fir is valuable for manufacturing pulp and paper products, although it can be susceptible to insect and disease problems.

Typical stands that should be replaced with more valuable tree species are:

(1) "Old" stands (mature-overmature)

Example: Balsam fir and white spruce stands will normally show a significant decline in growth by 40 years and may be considered mature. At age 60, they are usually overmature and may have started to deteriorate.

Trees can live longer than the average ranges outlined in Table 3. However, at some point they begin to decline, resulting in butt rot, dead tops, blowdown, and reduced height and diameter growth. At the older stage, it is more productive to harvest and ensure that the trees are replaced with healthy, young trees of desirable species. The old saying, "the timber on my woodlot is as good as money in the bank" may or may not be true, depending on whether your forest stands are growing (appreciating in value) or declining (depreciating in value).

(2) "Poorly Stocked" (understocked) stands of any age

Example: A well stocked stand of red spruce 40 years old will normally have 3,100 trees per hectare. A 40 year old red spruce stand that has had only 741 trees per hectare from the beginning will be poorly stocked with limby trees. These poorly stocked stands should be replaced, regardless of species.

(3) Immature stands with "low value" species

Example: Immature grey birch and aspen stands have very low commercial value and limited market opportunities in Nova Scotia. This is not likely to improve in the future. If these stands occupy a significant portion of the woodlot, it may be best to salvage any usable wood and restock the site with more valuable species.

Now that we have a general idea of which stands should be considered for stand establishment techniques, and assuming our objective is to grow primarily the most valuable species, what are the alternatives? How should clearcuts, partial cuts, shelterwood, or seed tree treatments be used? Should we plant after cutting or will natural regeneration restock the site?

The next two lessons will attempt to answer these questions by describing the common mature to overmature stand types on small woodlots in Nova Scotia and how to regenerate them.

**TABLE 3. AVERAGE EXPECTED RANGE OF MATURITY
FOR NOVA SCOTIA'S COMMERCIAL SPECIES.**

SPECIES	AVE. RANGE OF MATURITY
Balsam Fir, White Spruce, Poplar, Larch	40 - 60 years
White Birch, Black Spruce, Red Pine, White Ash, Red Maple, Beech*	60 - 80 years
Red Spruce, White Pine, Eastern Hemlock, Yellow Birch, Sugar Maple, Red Oak	80 - 100 years

*Beech is usually a longer lived tree, but Beech Bark disease greatly reduces it's life expectancy.

QUIZ

TRUE OR FALSE

- _____ 1. Spacings of 3m x 3m (10 ft x 10 ft) are best for early tree growth and form in Nova Scotia.
- _____ 2. A fully stocked stand with an average spacing of 1.8 m (6 feet) will have about 3,100 trees per hectare.
- _____ 3. Red spruce quickly regenerates abandoned fields and pastures throughout Nova Scotia.
- _____ 4. In two story stands, shade tolerant trees always overtop the shade intolerant trees.
- _____ 5. Yellow birch is considered tolerant to shade.
- _____ 6. White birch is considered a pioneer species.
- _____ 7. Our most valuable species are the shade intolerant trees.
- _____ 8. White spruce stands usually mature before age 60 in Nova Scotia.
- _____ 9. Poorly stocked stands usually grow more limbs than usable stem wood.
- _____ 10. Balsam fir dominates the climax forest types of western Nova Scotia.

LESSON TWO

NATURAL REGENERATION MANAGEMENT

Natural regeneration develops when seeds from surrounding trees fall to the forest floor or stump sprouts and root suckers develop on some hardwoods. This and other methods of reproduction are illustrated in Figure 6. To regenerate our forest stands naturally, it is necessary to understand the strategy for survival of each tree species.

STRATEGY FOR SURVIVAL

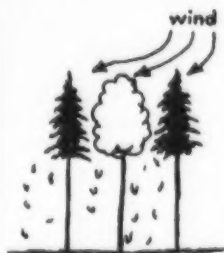
For each tree species we need to know:

1. At what age will a particular tree begin producing good seed crops?
2. How often do good seed years occur?
3. How far can seeds travel from the parent tree either by wind, squirrels or birds?
4. Once on the forest floor, how long will the seed remain good (viable) - a few weeks? a year? several years?
5. What type of seed bed is preferred by each species? How much moisture is required?
6. How much sunlight (full versus partial) is required to keep seedlings alive and growing? Are young seedlings usually present as advanced regeneration in mature and overmature stands?
7. Is the species capable of vegetative reproduction (sprouts, suckers)?
8. Using the answers to these questions, what cutting strategy can be used to ensure that the new stands will contain sufficient numbers of our preferred species?

Table 4 helps answer these questions by providing information for seven preferred species, as well as two aggressive competitors. If this all seems too complicated, we will help you so that it won't be complicated at all.

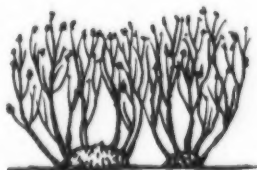
FIGURE 6. METHODS OF NATURAL REGENERATION

1. Seed



- Falls to the forest floor
- Germinates if it lands on a suitable seedbed.
- Survives and grows if light and moisture conditions are suitable.
- All species capable of seed production.

2. Stump Sprouts



- Follow cutting of most hardwoods, Red maple, Sugar Maple, Mountain Maple, White Birch, Grey Birch, Yellow Birch, Red Oak, White Ash, Beech, Aspen, Pin Cherry, and Alders.
- Sprouts grow best under full sunlight, shading reduces vigour.
- Rapid early growth as sprouts use existing root system of parent tree.
- Very common to have 10 - 20 good healthy stems per stump.
- Sprouting ability gives species such as Red Maple tremendous advantage after clearcutting - sprouts may be 1m (3.25 ft) tall within one year after cutting.
- Immature trees generally more vigorous sprouters than mature/overmature trees.
- Sprouts may be shorter lived and of lower quality than trees from seed.

3. Root Suckers



- Follow cutting of Poplar, Beech and possibly Sugar Maple, Red Maple.
- Full sunlight best, shading reduces vigour.
- Suckers produced from buds on the shallow lateral roots, usually within 8 - 10 cm (3- 4 inches) of soil surfaces.
- Suckers use parent roots initially, but soon develop their own roots.
- Suckering ability gives Aspen, Beech tremendous advantage after clearcutting as suckers can grow 2 m (6.5 ft.) in the first year.

4. Layering



- Lower branches become covered with moss, and eventually develop roots. Branch tips turn up toward the sky to form new tree.
- Black spruce can do this on swampy sites.

Table 4 FACTORS AFFECTING REGENERATION FROM SEED

	<i>Red Spruce</i>	<i>Black Spruce</i>	<i>White Spruce</i>	<i>Sugar Maple</i>
Optimum Seed Bearing Age (yrs.)	45 + yrs.	40 + yrs.	50 + yrs.	70 +yrs.
Interval Between Good Seed Years (years)	3 - 8 yrs.	4 yrs.	3 - 5 yrs.	2 - 5 yrs.
Average Number Cleaned Seeds per Kg (lb)	310 000/kg (140,000/lb)	880 000/kg (400,000/lb)	528 000/kg (240,000/lb)	13 200/kg (6,000/lb)
Seed Dispersal Dates	October - Spring	September - throughout yr	September - October	September - October
Seed Viability (growing seasons after seed matures)	1 growing season	Up to 4 growing seasons	1 growing season	1 growing season
Effective Seeding Range	60 m (200 ft)	30 m (100 ft)	60 m (200 ft)	45 m (150 ft)
Shade	Tolerant	Tolerant	Intermediate	Very tolerant
Favourable Seedbeds	Shaded light * humus or humus/mineral soil mixture	Mineral soil **sphagnum moss	Mineral soil Haircap moss or light grass	Shaded humu mineral soil mix or leaf litter
Additional Notes	Seedling survival poor on deep humus greater than 5 cm (2 in.)	Cones release seeds slowly over several years unless excessive heat causes rapid opening	Pine needle litter makes poor seedbed - soil disturbance helps	Hardy seedlin - no problem penetrating leaf litter

* Humus - Partly decomposed leaves/twigs etc. that has accumulated on the forest floor over many years.

** Sphagnum moss - grows in depressions that have free standing water at least part of the year . for example swampy areas and imperfectly drained sites.

<i>Yellow Birch</i>	<i>Red Oak</i>	<i>White Ash</i>	<i>Red Maple</i>	<i>Balsam Fir</i>
70 + yrs.	50 + yrs.	45 + yrs.	40 + yrs.	30 + yrs.
1 - 2 yrs.	2 - 5 yrs.	3 - 5 yrs.	almost every year	2 - 4 yrs.
1 000 000/kg (450,000/lb)	275/kg (125/lb)	29 000/kg (13,000/lb)	51 000/kg (23,000/lb)	132 000/kg (60,000/lb)
September - Spring	September - October	September - December	April - July	August - Spring
1 -2 growing seasons	1 growing season	1-2 growing seasons	1 - 2 growing seasons	1 growing season
60 m (200 ft)	20 m (60 ft)	45 m (150 ft)	60 m (200 ft)	60 m (200 ft)
Intermediate	Intermediate	Intermediate	Intermediate	Very tolerant
Partially shaded mineral soil or mineral/humus mix	Partially shaded mineral soil covered by leaf litter	Mineral soil and full sunlight	Almost any seedbed with moisture	Almost any seedbed with moisture
Roots too weak to penetrate leaf mats	Regeneration best at woodland edge-more light	Seeds remain viable for two years	Very strong competitor because of seeding/ sprouting abilities	Very strong competitor because of seeding and shade tolerance

The requirements for healthy seedling production for the seven preferred species are very similar. In general:

1. With the exception of yellow birch and sugar maple, they all begin producing good seed crops between 40-50 years of age. Smaller amounts of seed can usually be produced before these ages. Obviously, if stands are cut before optimum seed-bearing age, the chances of regenerating these species are reduced.
2. With the possible exception of red spruce, we can expect good seed crops at least every five years. This is not a long time in the life of a forest.
3. Most species have seed which are small enough to be carried by wind up to several hundred feet from the parent tree. Red oak seeds are too large to be windblown.
4. Their seeds all mature in early fall and spend the winter on the forest floor. Germination will occur in the following spring if the seed is good and it has landed on a suitable seedbed. Seeds are usually good for one year with the exception of black spruce, white ash, and yellow birch. Black spruce cones open slowly and can protect the seed so it may remain viable for several years, while yellow birch and white ash may remain viable for two years.
5. All seven species are intermediate to very tolerant of shade. Except for pure stands of white spruce and black spruce, these species will regenerate from seed with some form of shelterwood system.
6. All species prefer mineral soil seedbeds, but frost heaving can be a problem. A mixture of mineral soil and humus is the preferred seedbed because it is less likely to dry out in summer and is the best medium for roots to extract nutrients and water. Sugar maple and white ash have an advantage with their large taproots that can penetrate leaf litter on the forest floor, whereas the other species cannot. Skidding with horses and winching with farm tractors or skidders is an excellent way to mix mineral soil with humus in shelterwood cuts.

These points show some of the similar characteristics which exist for the seven tree species covered in Table 4. As summarized, most of these species will regenerate after some form of shelterwood system. However, this does not eliminate the possibility of using alternate forms of clearcutting, selection, or seed treed systems.

The final decision would also need to consider other information; such as, the woodlot owner's objectives and the required volumes or stocking levels needed for the treatment to be successful.

Clearcutting is the most common method of harvest. It can provide an opportunity for other tree species listed in Table 4. In 1987, red maple made up 15 percent and balsam fir made up 18 percent of the total growing stock in Nova Scotia and both are increasing at the expense of more valuable species.

Let's summarize the factors from Table 4 that enable red maple and balsam fir to be so competitive.

Red Maple

- begins producing good seed crops by 40 years of age
- produces good crops almost every year (prolific)
- seeds are produced in spring, fall by early summer and germinate soon after (get a one year head start on preferred species whose seeds generally overwinter)
- seeds can germinate and grow on almost any type of seedbed and under full sunlight or partial shade
- red maple is a very prolific stump sprouter; with its tremendous ability to produce sprouts and to some extent seedlings, red maple can take advantage of almost any type of disturbance in our forests

Balsam Fir

- begins producing good seed crops by 30 years of age and produces good crops every 2-4 years
- seeds will germinate and grow on almost any type of seedbed
- seedlings often outcompete red spruce under similar seedbed conditions because they are larger and have a taproot which enables them to withstand drought
- very shade tolerant; seedlings are able to survive and grow slowly under heavy shade

Unlike red maple which starts quickly after disturbance, balsam fir's strategy for survival usually begins long before any disturbance takes place. Balsam fir produces seed at an earlier age than most of its competitors. The seedlings can survive for many years in the understory of most of our forest stands, ready to take advantage of any openings created in the overstory.

If you want reduce balsam fir and red maple on your woodlot, practise shelterwood cutting to ensure adequate regeneration of other tolerant species. Later, precommercial thinning of the young trees can favour the most desirable species.

If your area is dominated by balsam fir, you may want to adopt a modified management strategy to optimize the use of this species.

Let's now discuss the different cutting systems that are available to establish natural regeneration. The following descriptions of the shelterwood, clearcutting, selection, and seed tree methods are simplified versions of those previously discussed in the Woodlot Management Home Study Course entitled "Harvesting Systems".

As a good example, the shelterwood system will be discussed in slightly more detail to illustrate the establishment of natural regeneration.

SHELTERWOOD CUTTING SYSTEM

The following is a simplified version of shelterwood cutting as previously discussed in the Home Study Course module entitled Harvesting Systems.

Shelterwood cutting is the removal of mature timber in two or three partial cuts which extend over 10-20 years. The system encourages evenaged regeneration of preferred species under the partial shade of valuable seed trees. Figure 7 illustrates the shelterwood cutting system.

The 30-50 percent basal area removed in the first cut is designed to:

- leave the most desirable trees to provide seed
- allow enough light to reach the forest floor to encourage reasonably good seedling germination and growth
- prevent excessive drying of the top layers of the forest floor by offering 40-70 percent shading, so that more moisture is available for seedling growth
- restrict competition from shade intolerant trees such as pin cherry, aspen and white birch, and other aggressive plants such as grasses and raspberries

To better understand the effect of shading on the forest floor, compare the edge of a 5-10 year old clearcut to a dense stand of shade tolerant trees (Figure 8). Forest stands along roadways can also provide an excellent opportunity to view the benefits of shading.

Shelterwood cutting uses partial shading to give the more valuable species the competitive edge at the seedling stage. When the seedlings become well established, the overstory can be removed. Well established softwood seedlings are at least 0.3 m (1 ft) tall with firm roots in mineral soil. The seedlings are now able to hold their own against the competition and grow best under full sunlight.

Shelterwood cutting is a very good way to promote natural regeneration of desirable species. Here are some guidelines that can improve the prospects for success.

Pre-cut Stand Assessment:

Walk through the stand before you begin cutting. Note the regeneration; check the forest floor closely since some seedlings, such as red spruce, are very small. Also note

FIGURE 7. SHELTERWOOD CUTTING SYSTEM

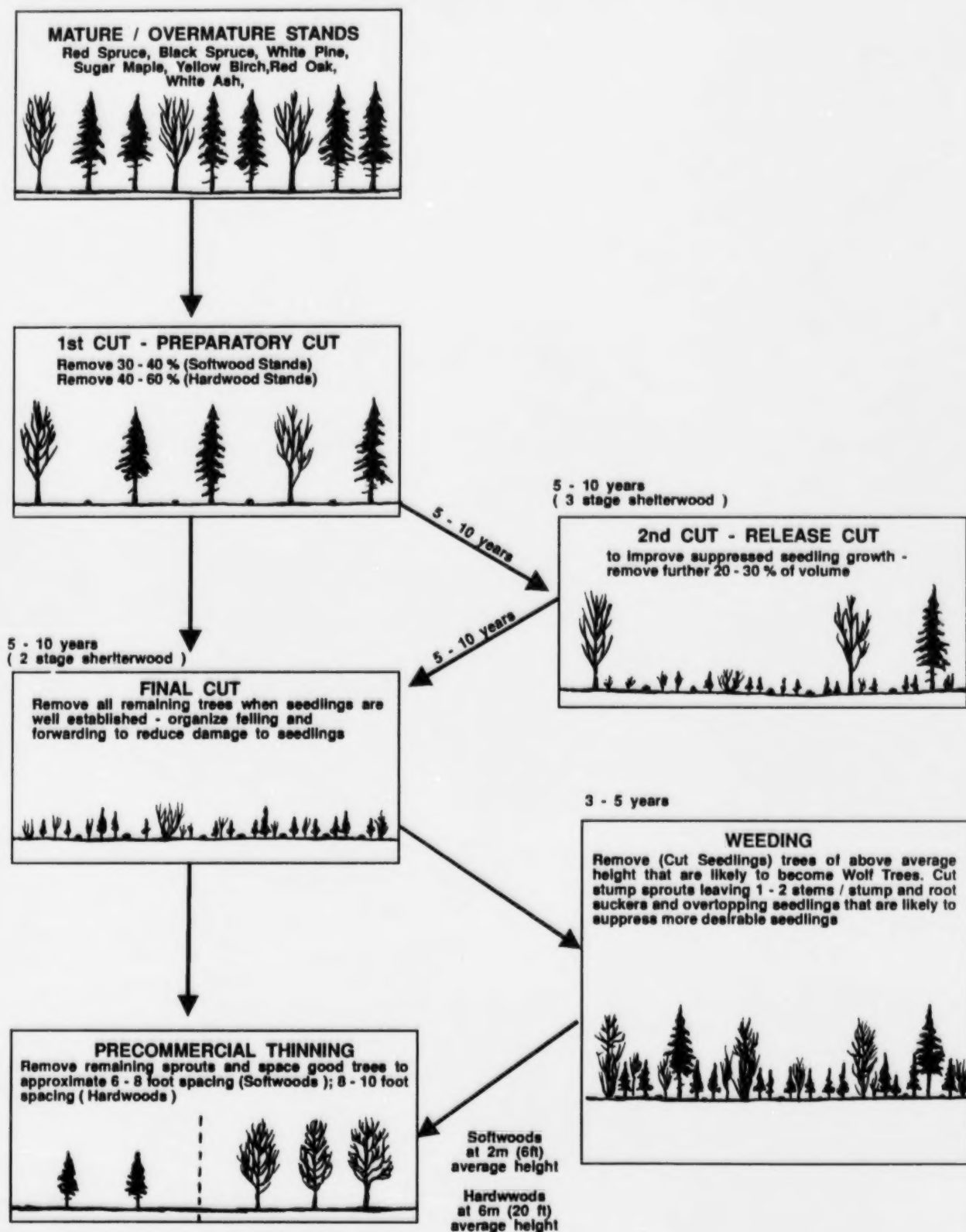
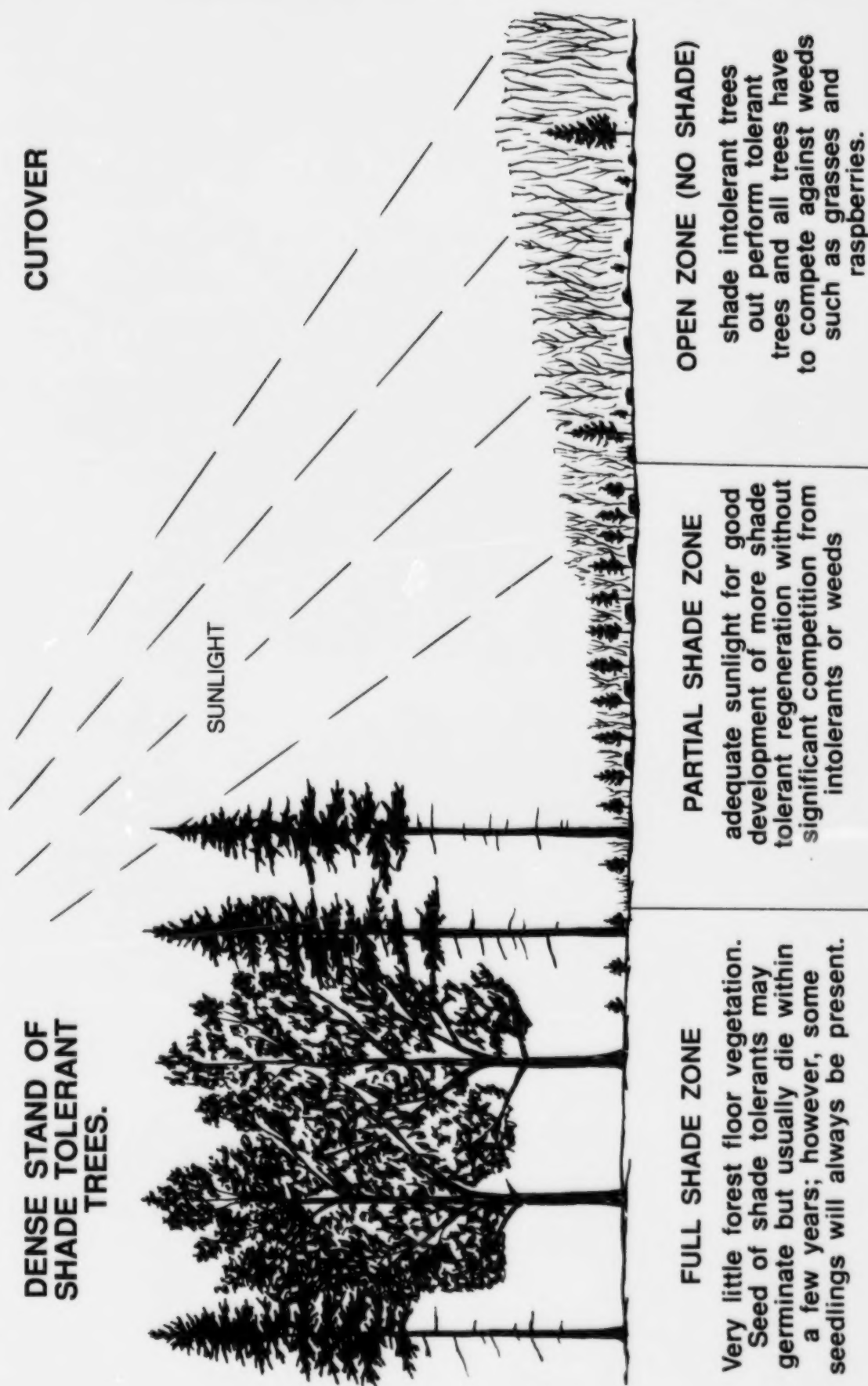


Figure 8. Shade Zone Effects on Forest Floor Vegetation.



potential seed sources of the most valuable species. Assess site and stand conditions and make a mental plan of how you will proceed to: (a) minimize damage to existing desirable regeneration and (b) encourage additional regeneration establishment. Refer to Figure 5 for help.

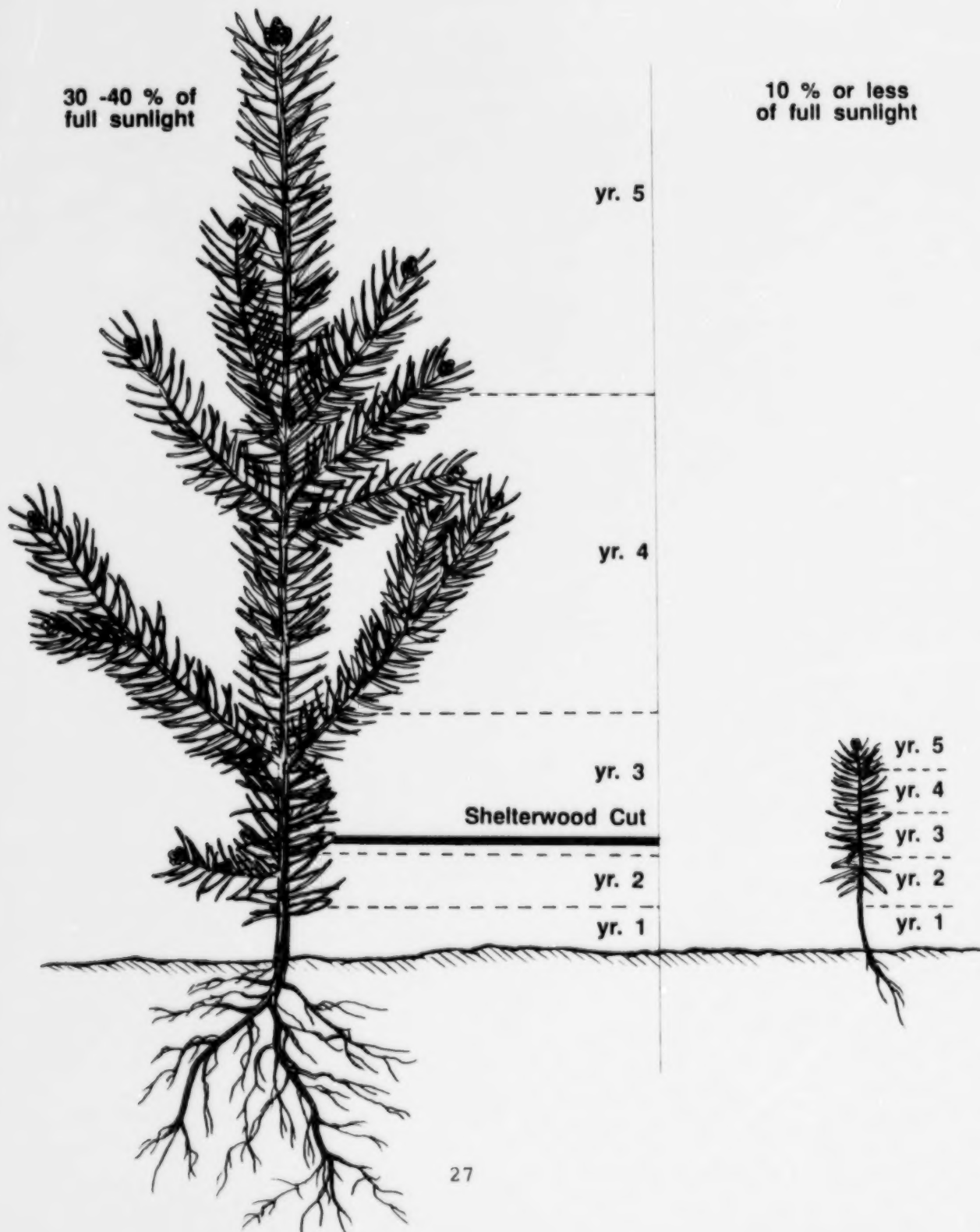
First Cut:

- Remove all salvageable dead and suppressed trees that will likely die from overcrowding before the next cut. This is called thinning from below.
- Remove as many wolf trees as possible without opening the stand too much. Wolf trees are difficult to directionally fall and can cause damage to established regeneration during the final cut.
- Remove poor quality regeneration of above average height.
- Ensure that sufficient trees are removed to provide uniform light conditions throughout the stand. Do not leave dense patches where ground shade will prevent regeneration establishment.
- In mixedwood stands, leave as much hardwood as possible for shade and for seed. Hardwoods are more windfirm than softwoods and are easier to cut without damaging regeneration at later stages.
If desirable advanced regeneration already exists, less valuable hardwoods such as red maple and aspen can also be left. Red maple and aspen sprouts and suckers will be easier to deal with after the final cut.
In stands with white birch and red maple, cut the white birch first since it is usually shorter lived and doesn't sprout like red maple.
- Improve seedbed conditions by organizing the work to disturb the ground. Skidding and winching the harvested trees will help mix the mineral soil and humus.

Second Cut:

- Several years after the first cut, the openings in the crown canopy may be closed, allowing insufficient sunlight for good seedling growth. Therefore, a second cut to open the dense areas of the stand may be necessary to improve light penetration. Figure 9 illustrates the effect of increased light penetration on seedling growth.

FIGURE 9. COMPARISON OF RED SPRUCE SEEDLING GROWTH AT TWO DIFFERENT LIGHT REGIMES.



Final cut:

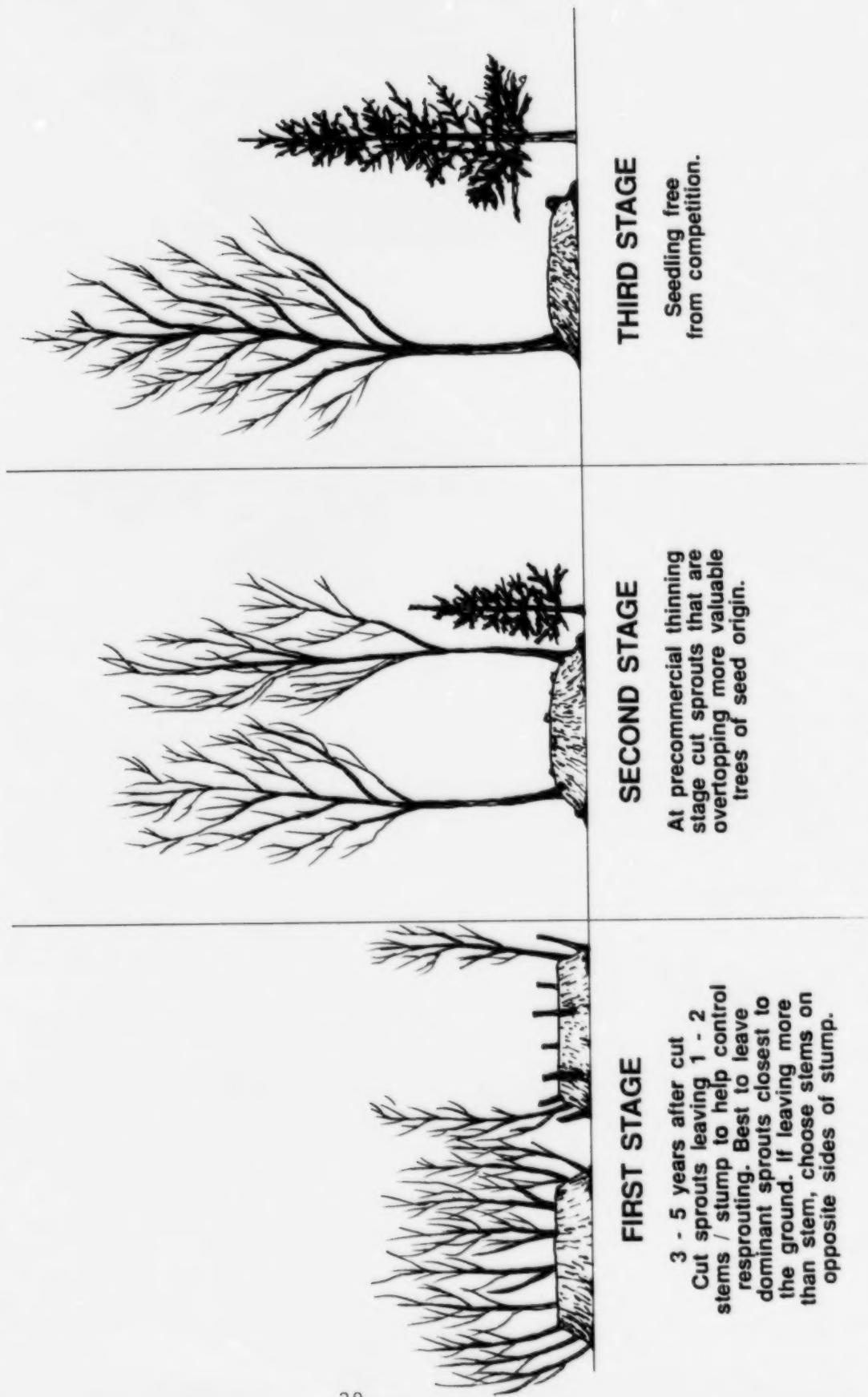
- Organize felling and forwarding to minimize damage to regeneration. The shortwood system is best for the final cut since the wood is carried to roadside by forwarder or tractor-wagon. Trees should be felled toward extraction trails so that tops land in the trails and cut slash helps to reduce soil damage.
- Tree length extraction is not recommended because of excessive damage that is likely to happen to young seedlings.

Follow-up Treatments

Conduct a weeding operation within 3-5 years of the final harvest. Cut stump sprouts and other regeneration of above average height that overtop the desirable regeneration. Leave 1-2 stems per stump to help control resprouting (Figure 10). It is important to delay this weeding operation until the sprouts and suckers begin to seriously interfere with seedlings.

Finally, since these naturally regenerated stands will usually have too many seedlings for good stand growth and tree form, a precommercial thinning may be required. A precommercial thinning generally starts when the trees are 2 m (6 ft) tall in stands dominated by softwoods and 6 m (20 ft) tall in stands dominated by hardwoods. It is best to wait longer before spacing hardwoods to let the crop trees develop at least one log length of clear wood. Hardwoods are spaced wider than softwoods because they are older when thinned and additional space is needed to maintain good diameter growth.

**FIGURE 10. MANUAL CUTTING TO CONTROL
SPROUT DOMINANCE.**



CLEARCUTTING

Clearcutting is the removal of all, or most, of the trees on a piece of forested land during one harvest operation. It is the most common method of harvest used in Nova Scotia.

Clearcutting is an evenaged form of management because most of the trees that are cut are the same size and age.

Fortunately, our climate is very favourable for tree growth. As such, 67% of all clearcuts regenerate naturally to commercial species. In those areas that either do not or cannot regenerate naturally, artificial regeneration may be needed.

When applied properly, clearcutting is a safe and effective way to manage your stands. It is suited to stands of overmature trees; areas extensively damaged by fire, insects, diseases, or wind; and stands that have been highgraded or are composed of poor quality trees. Before clearcutting, an assessment should be made of the existing regeneration and a forecast made for possible seedling establishment after the cut.

Alternate clearcutting methods also include strip and patch cuts which encourage natural regeneration establishment. As previously noted, more information on these alternatives is given in an earlier Home Study Course module.

SELECTION CUTTING SYSTEM

Selection cutting is the removal of trees from a stand to provide a steady flow of forest products from the woodlot. This unevenaged management system can remove single trees, groups of trees, or strips of trees from a stand. It differs from shelterwood cutting and clearcutting which are evenaged management systems.

Selection management should not be confused with diameter-limit cutting in which trees less than a certain diameter are not harvested. This can result in "high-grading" where you "take the best and leave the rest" because the small trees are not always young ones.

Selection cutting is a complicated system which combines aspects of shelterwood cutting, precommercial thinning, and merchantable thinning to maintain stands with trees in at least three age classes.

Unfortunately, selection management has its disadvantages. Compared to the evenaged cutting practices, this system requires more skill when selecting trees to be cut. Selected trees need to be good quality, tolerant, and long-lived (80+ years) species that are windfirm and able to survive with less than full sunlight.

An extensive road and trail network are also required to remove the low volumes on each acre.

If you want to try the selection system on your woodlot, ask forestry personnel for help.

SEED TREE SYSTEM

This method of stand establishment is a modification of clearcutting, except that scattered good quality, mature trees are left to provide seed for a new crop.

This system can be used very successfully to regenerate white pine in Nova Scotia. For white pine, leave 20-30 good quality, healthy seed trees per hectare (8-10 trees per acre), preferably in semi-straight rows, to make future cutting of the seed trees easier when regeneration becomes well established. White pine is suited to this system because it is a very windfirm species.

The following factors allow white pine to regenerate and compete after clearcutting:

- (1) Its intermediate shade tolerance allows it to compete with species such as raspberry, pin cherry, and hardwood sprouts which usually regenerate clearcuts.
- (2) It usually grows on poor, dry sites where there is less competition with other tree species and shrubs than there is on fertile sites.

Regardless of which harvesting system is used to promote natural regeneration, it is important to do a pre-cut stand assessment to determine which system is best for your woodlot.

STAND TYPES SUITABLE FOR NATURAL REGENERATION MANAGEMENT

Here are some examples of common mature and overmature stand types that are suitable for natural regeneration management and the results that can be expected from a shelterwood cut.

Red Spruce Stands

Red spruce is a valuable tree in Nova Scotia. It responds well to natural regeneration management. Stands may be pure red spruce or comprised of at least 30 percent red spruce.

Sample stand types are:

- red spruce
- red spruce, balsam fir
- red spruce, white pine
- red spruce, red maple

As Table 3 in Lesson 1 indicates, red spruce usually matures in 80-100 years. There are a few situations where red spruce stands begin to deteriorate at 40-50 years. In these stands, shelterwood cutting should be started early. These include:

- (1) some old pasture lands where red spruce has developed excessive butt rot
- (2) stands in poor health because of porcupine or insect damage
- (3) stands with greater than 40 percent short lived species, such as balsam fir, aspen, and larch

Where it occurs naturally in Nova Scotia, red spruce regenerates well when the shelterwood method is used. Usually, the forest floor under mature red spruce stands is covered with tiny red spruce seedlings from previous seed years. Our major objective in these stands is to ensure adequate sunlight for good seedling growth. In many cases, the first and second cuts of the shelterwood system can be combined and the period from the initial to the final cut may be within 5-10 years. In stands where red spruce is mixed with shade tolerant species such as eastern hemlock and sugar maple, crown closure is usually so tight that red spruce regeneration is unlikely to become established. In this situation, the shelterwood process will require three cuts as noted in Figure 7.

In red spruce stands with a high proportion of balsam fir, the regeneration may be dominated by the more competitive and generally larger balsam fir seedlings. A precommercial thinning which favours red spruce can change this situation. In some instances, young stands with high proportion of balsam fir can be converted to primarily red spruce. For example, a 1.8 x 1.8 metre (6 ft x 6 ft.) plot may have nine balsam fir seedlings and one red spruce seedling before precommercial thinning, but only the red spruce seedling after precommercial thinning.

Red spruce does not occur extensively on Cape Breton Island because of the generally harsh, cool climate. Some red spruce planted on well drained, sheltered sites, such as inland valleys, is expected to grow reasonably well.

There are many hardwood stands that are well stocked with red spruce regeneration of various sizes. The seeds may have come from scattered red spruce trees either in the stand, in red spruce stands nearby, or in many cases, from the trees that were removed.

Gradually opening these stands through shelterwood cutting will allow them to convert to predominantly red spruce. These types of stands show us the importance of pre-cut assessments for good stand establishment techniques.

Balsam Fir Stands

These stands may be pure stands of balsam fir or stands where balsam fir is the major species.

Sample stand types are:

- balsam fir
- balsam fir, red spruce
- balsam fir, red maple
- balsam fir, yellow birch

Balsam fir stands tend to develop well after a clearcut since advanced regeneration is usually present. This regeneration is present because balsam fir produces seed at an early age and generally begins to deteriorate before reaching 40. Only in limited areas, such as the Cape Breton Highlands, can balsam fir remain healthy for longer periods of time.

Shelterwood cutting is not necessary for balsam fir stands. To establish a stand on a woodlot dominated by balsam fir, you could:

- Manage the stands on very short rotations of 35-40 years to reduce losses to balsam woolly aphid and butt rot.
- Attempt to improve the species mix by carrying out a precommercial thinning or merchantable thinning.
- Replace the stands on better sites with valuable, long lived species using artificial regeneration techniques, such as planting.
- Consider managing for Christmas trees if you have the time and markets are available.

White Pine Stands

These are pure stands or mixed stands where white pine comprises a major component.

Sample stand types are:

- white pine
- white pine, red spruce
- white pine, red oak
- white pine, red maple

White pine regenerates very well in Nova Scotia when one of the following systems are used:

- (1) shelterwood system
- (2) clearcutting with seed trees (20-30 trees/ha or 8-12 trees/acre)
- (3) clearcutting immediately following a good seed year

Intermediate in shade tolerance, white pine seed can germinate and grow under partial shade created by the shelterwood system or under full sunlight created by clearcutting. Adequate soil disturbance provided by skidding or winching will help improve regeneration results, regardless of which system is used.

White pine weevil is a very serious pest that usually makes its home in the leaders of the largest, fastest growing trees. Affected trees become crooked and are generally worthless. When these stands are between 6-9 metres (20-30 feet) tall, a precommercial thinning can reduce the impact of weevil damage. Trees over 10 metres (35 feet) tall rarely sustain weevil damage. Cut the deformed trees and favour straight-stemmed, co-dominant and intermediate trees, spacing the trees approximately 2-3 m (6-10 ft) apart.

White pine has traditionally been a valuable tree. Managing individual trees or stands of white pine by using good stand establishment techniques, weevil control, thinning, and pruning to produce clear wood may bring worthwhile benefits to woodlot owners in the future.

Tolerant Hardwood Stands

These may be pure stands of sugar maple or stands of sugar maple mixed with yellow birch, beech and lesser amounts of red maple, white birch, white ash, eastern hemlock, red spruce, and striped maple.

Sample stand types:

- sugar maple
- sugar maple, beech
- sugar maple, balsam fir
- sugar maple, yellow birch, balsam fir

Our general objective in managing these stands is to grow straight, clear stems of sugar maple, yellow birch, and white ash to a diameter of 30-35 cm (12-14 in.). Hardwood logs reach their maximum value when the diameters are equal to or greater than about 32 cm (13 in.). Fully stocked tolerant hardwood stands with an average diameter of 32 cm (13 in.) will have approximately 350 trees/ha (140 trees/ac.).

These species usually begin to mature at 80 years (Table 3), at which point regeneration establishment can be considered. Establishment practices should be considered at an earlier age for poor quality stands with less than 200 stems/ha (80/ac) of yellow birch, sugar maple, and white ash.

Sugar maple and white ash have large seeds and require similar seedbeds. Their seedlings can penetrate hardwood leaf litter (matts). Yellow birch has very small seeds and may require some soil disturbance provided by skidding or winching trees to create suitable exposed mineral soil.

Figure 7 gave a general idea of the shelterwood cutting method presently recommended in Nova Scotia. In hardwood stands, more volume is removed in the first cut than from softwoods. With hardwoods, the release cut can be omitted in favour of the final cut when the average height of the regeneration is 0.5-1.0 m (1.5-3 ft.). The ideal time for the final cut is when most seedlings are more than 0.5 m (1.5 ft) tall and have shown growth of at least 15 cm (6 in.) during the previous growing season. These seedlings will be well established and will no longer need the benefit of overhead shade, but are still small enough that the risk of damage during final felling will be low.

Since sugar maple, white ash and red maple are vigorous stump sprouters, sprout control is very important if the new stand is to be well stocked with young trees of seed origin. Sprouts can quickly outgrow seedlings. Three years after final harvest, a sprout may be 3 m (10 ft.) while a seedling may be about 0.5-1.0 m (2-3 ft.).

Expect young hardwood stands to be approximately 12 metres (40 ft.) tall at 40 years, at which time a second thinning will be required to maintain good diameter growth.

QUIZ

TRUE OR FALSE

- _____ 1. Red spruce produces good seed crops every year.
- _____ 2. Red maple stumps usually sprout vigorously after cutting.
- _____ 3. Sugar maple and white ash have large taproots that can penetrate leaf litter on the forest floor.
- _____ 4. Balsam fir seedlings outcompete red spruce seedlings under similar seedbed conditions.
- _____ 5. Clearcutting usually favours the establishment of shade tolerant species.
- _____ 6. Ground disturbance, such as mixing of mineral soil and humus by skidding or winching, is beneficial to seedling development in shelterwood cuts.
- _____ 7. Shortwood harvesting is not suitable for the final cut in the shelterwood system.
- _____ 8. Ten percent of full sunlight is sufficient for excellent growth of red spruce seedlings.
- _____ 9. The seed tree method can be used very successfully in regenerating white pine in Nova Scotia.
- _____ 10. Stump sprout control is not an important factor to consider when carrying out shelterwood cutting in tolerant hardwood stands.

LESSON THREE

ARTIFICIAL REGENERATION MANAGEMENT

INTRODUCTION

Artificial regeneration of softwood begins when cones are collected from the forest or from special seed production areas called seed orchards. Seed orchards contain trees grown from seed or shoots from the very best trees, often called "plus" trees. The seeds are extracted mechanically and stored under controlled conditions.

Seeds are germinated and grown into seedlings in forest nurseries. Softwood species dominate artificial regeneration programs. Hardwood seedlings are more difficult and expensive to produce and planting success is poor. This text will deal exclusively with planting softwood.

In 1989, approximately 10 million trees were planted on small woodlots in Nova Scotia. At 3100 trees per hectare (1200 trees/acre), these trees occupy about 3,400 hectare (8,300 acres). In addition, approximately 15 million trees were planted on Crown and large company lands in 1989.

An owner whose woodlot is dominated by healthy red spruce, yellow birch, sugar maple, and beech may not understand why we need to plant so many trees. This is especially confusing when it seems that the forest can regenerate itself, as discussed in Lesson 2. The forests of the province can be quite different from one area to the next. A woodlot owner in Cape Breton whose balsam fir and white spruce stands have been devastated by spruce budworm and spruce bark beetle during the past 15 years may not have an option other than to clearcut the site and replant to restore productivity.

Planting is usually recommended on private woodlots in the following cases:

- (1) mature and overmature stands that will not likely regenerate naturally, such as white spruce, or that will regenerate to undesirable species.
- (2) non regenerating, understocked, stands, regardless of species composition, since the site is not being fully utilized, if it will not likely improve.
- (3) young stands stocked with low value species such as grey birch, white birch, aspen, or beech.

- (4) stands that have been damaged by insect, disease or fire and which will not regenerate naturally.

PLANNING

As with natural regeneration, the most important thing to do before making the final decision to plant is to walk through and thoroughly assess the stand prior to harvest. This will:

- reveal the presence of regeneration on the forest floor, or the potential for future regeneration. Generally, small cutovers of less than 2 ha (5 ac.) that have good adjacent seed sources will regenerate satisfactorily. It is unnecessary and wasteful to plant areas that will regenerate naturally.
- indicate the potential hazard for rabbit browsing in the area. Rabbits can browse up to 10 rows of seedlings along the edge of cover, which may be 75 percent or more of the trees in a small plantation. Regardless of species, rabbits prefer nursery grown seedlings to natural seedlings because of their high nutrient value. Large plantations without weed control also provide good "cover" for rabbits and are high risk for browsing.
- identify and predict the vegetation, other than trees, that may affect the future plantation.
- uncover any insect or disease problem common in the area.

Note: All softwood and mixedwood cutovers must be left for two years before planting to eliminate the risk of damage by the seedling debarking weevil which lives in new slash. This will also provide an opportunity for natural regeneration to become established.

Use the following criteria to decide which method of harvest may be best when site preparation and planting are included as part of the total operation:

Ecologically	Which method will minimize site disturbance and nutrient removal and reduce the risk of fire?
Financially	Which method will pay the highest stumpage rates and result in the lowest future treatment costs (eg. site preparation)?

Technically	Is there sufficient landing space for the various logging systems available? Is risk of seedling debarking weevils high?
Finally	What type of harvest is best for your particular stand versus what is available? Do you have a choice?

If your assessment indicates planting is needed, plan for the following aspects of the operation:

- (a) harvesting method
- (b) site preparation
- (c) planting
- (d) plantation maintenance and weeding

Good planning may allow you to do something at one stage that will make future treatments easier and cheaper. The most successful artificial regeneration efforts usually begin with a well planned harvest operation. As an example, you may be able to harvest in a way that will eliminate the need for site preparation.

Now, let's discuss these aspects of artificial establishment of a stand.

Harvesting Method

In Nova Scotia, harvesting is carried out in one of the following methods:

1. Whole-Tree Harvest: Trees are felled, skidded or forwarded to roadside, with limbs and tops, leaving a relatively bare site.
2. Shortwood Harvest: Trees are felled, delimbed, and bucked to length at the stump leaving limbs and tops on the site. Wood is carried to roadside by a forwarder or tractor-wagon.
3. Tree-Length Harvest: Trees are felled, delimbed, and skidded tree length to the landing.
4. Random-Length logging is a system similar to #3. Random-length products are skidded or forwarded to a landing.





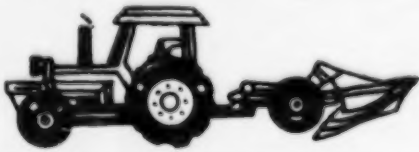
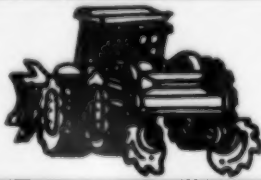


Site Preparation

The primary objective of site preparation is to create as many suitable planting spots as possible. Suitability for planting means easy access for planters and sufficient suitable microsites for seedling survival and growth. These microsites generally have adequate drainage, mineral soil and humus mixtures, and minimal weed competition.

Sites logged using the whole-tree harvest system may not require site preparation because the site is generally clear of logging slash. On sites logged using the shortwood or tree length systems, limbs, tops and unmerchantable debris may hamper the ability of planters to reforest the area. In this case, slash must be reduced or rearranged by one of the methods shown in Figure 11.

The brushrake and burn system was the site preparation method most widely used in Nova Scotia. The popularity of this system has declined because of concerns about fire hazards and nutrient loss associated with burning. The debris crushing system and corridor raking will likely become more popular since most logging debris stays on the site. The possible serious environmental impacts, including nutrient loss from whole tree harvesting, is a concern for both the public and some forestry experts.

**FIGURE 11. SITE PREPARATION EQUIPMENT
USED PRIOR TO PLANTING.**

	FINNISH PLOW	Production Prime Mover H.P. Required Weight Length Width	- 0.4 - 0.5 ha/hr - Crawler Tractor - 180 Plus - 3200 kg - 5.4m - 2.55m
	SHARKFIN BARRELS	Production Prime Mover H.P. Required Weight Length of Barrel Diameter of Barrel	- 1.0 - 3.0 ha/hr - Skidder - 170 Plus - 410 kg Empty, 780 kg full - 76 - 122 cm - 30, 41, 46, 51, and 61 cm
	HYDRO AXE	Production Prime Mover H.P. Required Weight Length Width	- 0.4 - 0.8 ha/hr - Hydro Mower PM-800 - 125 - 180 - 7000-11000 kg - 5.5 - 7.6 m - 2.4 - 2.7 m
	DISK	Production Prime Mover H.P. Required Weight Length Width	- 0.4 ha/hr - Dozer - 210 Plus - 11 Tonnes - 4.6 m - 3.6 m
	SINGLE FURROW PLOW	Production Prime Mover H.P. Required Weight Length Width	- 0.4 - 0.6 ha/hr - Farm Tractor - 35 Plus - 100 kg - 1.0 m - 0.5 m
	TTS TRENCHER	Production Prime Mover H.P. Required Weight Length Width	- 0.4 - 0.5 ha/hr - Skidder - 100 - 180 - 2040 kg - 2.1 m - 3.6 m
	CHOPPER	Production Prime Mover H.P. Required Weight Length Width of Drum	- 0.4 - 1.2 ha/hr - Crawler Tractor - 125 Plus - 11t empty, 15t full of water - 5.5 m - 2.1 m
	BRUSH RAKE	Production Prime Mover H.P. Required Weight Length Width	- 0.4 - 0.6 ha/hr - SKidder - 100 - 150 - 830 kg - 0.5 m - 2.5 m

Planting

Lesson 1 described how each tree species competes under a particular set of site factors which include drainage, fertility, competing vegetation, and exposure. When deciding which species to plant, consider the site factors and choose the species that are likely to compete and grow best under the existing conditions.

A general guideline of species selection is given in Table 5.

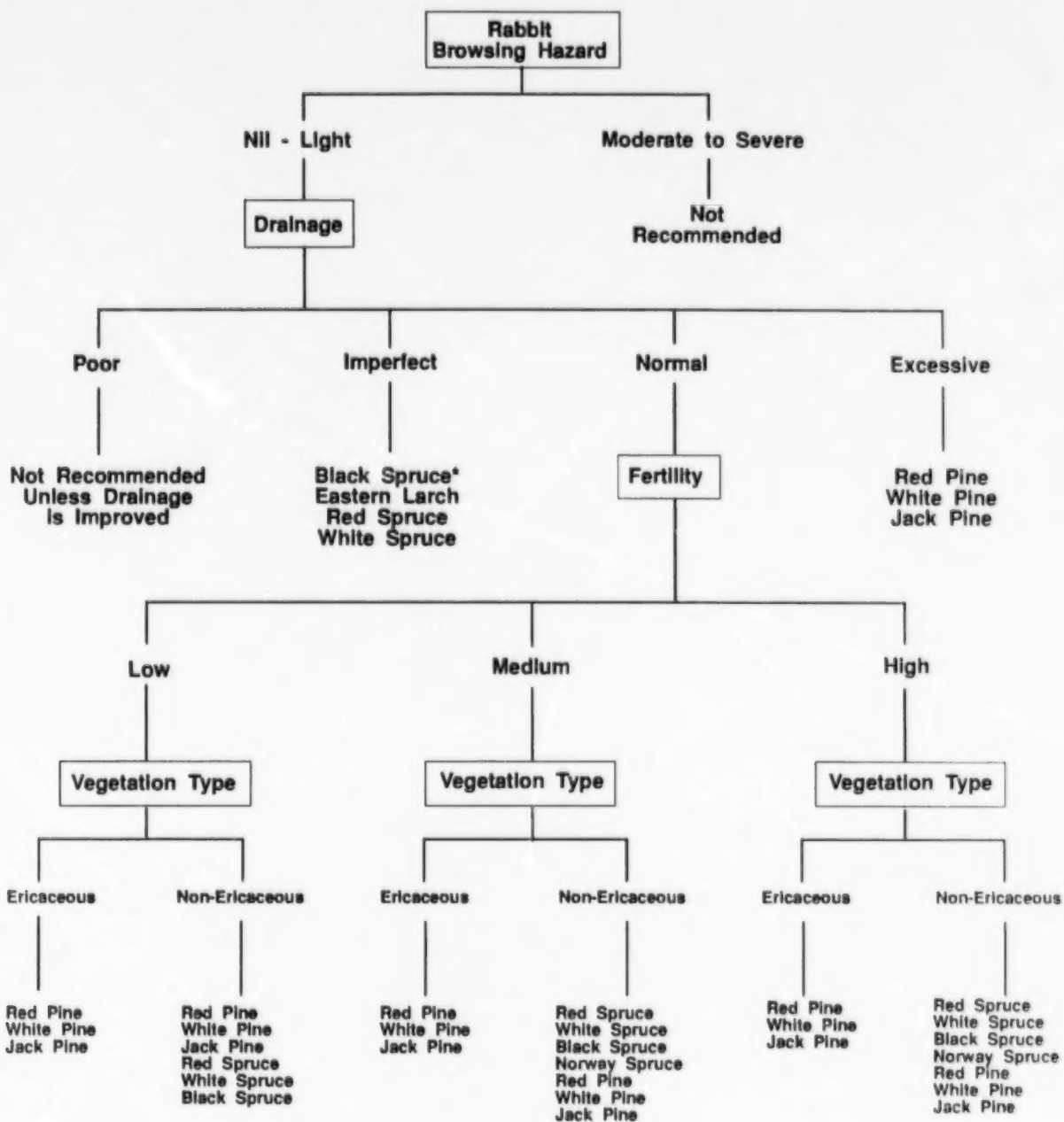
The following are examples of species that will do better on well drained, fertile sites, but due to their silvic requirements, they can survive on these less favourable sites.

- black spruce and larch are able to grow on wet sites
- white spruce will do well on very exposed sites because of its ability to withstand salt spray, wind, and winter drying conditions
- pines will grow on very dry, sandy sites with low fertility because of their deep rooting system and low nutrient requirements

If the site is not suited to the species you prefer to plant, site improvements can be made by:

- ditching or ploughing to improve soil drainage
- fertilizing to improve soil fertility
- using mechanical or chemical weed control to help reduce competing vegetation

FIGURE 12. SPECIES TO PLANT KEY



Species within blocks are ranked in order of priority, from top to bottom.

* Imperfectly drained ericaceous sites should be plowed prior to planting Black Spruce or Eastern Larch.
Red Spruce and White Spruce not recommended for these sites.
Ericaceous sites revert to non-ericaceous with adequate site preparation.

The flow chart and explanations above have been adapted from the Nova Scotia Department of Natural Resources Forestry Field Handbook. Choosing the best species for a site can involve other factors. Please consult qualified forestry personnel.

Nursery Stock

When you have decided which species to plant, the following nursery stock types may be available:



Container

- best on sites with little or no vegetation and shallow duff layer
- easiest stock to plant, especially on very rocky and stony sites
- plant using a hoe pipe or dibble



Small Bare Root

- stock similar in size to container
- best on sites with moderate duff depths, few rocks, and with little vegetation
- plant using shovel or Wifsta hoe



Large Bare Root

- large sturdy stock, but expensive to grow and plant
- best on sites with competing vegetation or on bare mineral spots to help reduce frost heaving
- plant using shovel or Wifsta hoe



Forestry Pellets

- best on sites with little or no vegetation and shallow duff layer
- easiest stock to grow, especially on very rocky and stony sites
- plant using a hoe pipe or dibble

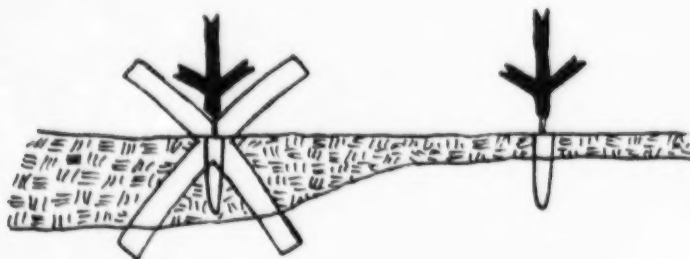
Planting Spot Selection

Planters ultimately decide where each seedling should be planted. The following are general guidelines for choosing suitable planting spots or microsites:

- Plant on the tops and sides of mounds, never in depressions where water collects and roots will suffocate.



- Avoid planting on rotten wood or thick duff because seedling roots need to contact mineral soil. Clean some of the duff away using your boot or planting tool.



- Avoid bare mineral soil because frost heaving will likely occur.



- Do not plant in excessively weedy or grassy spots because the competition may choke out the young trees.



Timing

Choosing the best time of year to plant will help increase the chances of success. Adequate soil moisture is the most critical factor affecting early survival and growth. For best results, plant in the spring soon after the frost leaves the ground (April 15-June 15) or in late summer (August 1 -September 15). Avoid planting during the potentially hot, dry period of early summer.

Seedlings planted after mid-September have less time to establish their roots and become more susceptible to winter drying or burning from insufficient snow which protects seedlings from winter winds.

Additional Planting Considerations

1. Markets

It is difficult to predict the changes in markets in 30-40 years. Red pine and larch currently have low market potential. However, specific products from these trees may have future possibilities. For example, good quality red pine trees will always be in demand for utility poles.

2. Old Fields

Grassy fields and pastures provide heavy competition for seedlings. Without using site preparation such as ploughing, white spruce and Norway spruce are the best choices.

3. Insect Damage

Are there common insects or diseases in your area?

White pine weevil occurs throughout the province and can severely affect young, healthy trees. Planting seedlings close together may help to reduce this problem, but will not eliminate it. You may want to discuss the situation with a local forester or forest technician.

As mentioned earlier, some areas of Nova Scotia have a small insect called "Hylobius congener" or "seedling debarking weevil" which causes severe damage in some newly established plantations. The weevils are attracted to newly logged areas and feed on the inner bark of freshly cut stumps and slash. When this food source disappears, the weevils turn to other food sources, which may be newly planted seedlings. Their feeding usually girdles the small seedlings which then die. In central Nova Scotia where the risk of weevil is high, logged areas are not replanted for at least two years after cutting. This gives the weevils time to eat and leave the site. Most forestry personnel in Nova Scotia are aware of the problem and can tell you how to proceed, depending on weevil risk in your area.

Plantation Tending

When seedlings are established, plantations should be tended to ensure that the young seedlings are sufficiently free of competition to grow properly. This is especially important during the first 5-10 years until the plantation is at a "free to grow" stage.

The establishment of plantations is similar to the pioneer stage of succession. After the mature trees are harvested, plants and shrubs will try to become established on the site. Examples of this vegetation include raspberry, grass, pin cherry, alder, and aspen.

Let's look at the two types of competition that may affect young planted seedlings.

Competition for Space

■ Example: Red spruce planted on grassy fields

Without ploughing or chemical weed control, red spruce does not compete well against grass for root space. Seedlings may die or grow very slowly. Insufficient moisture and nutrients can result in pale green or yellow foliage.

Ploughing or using a registered herbicide before planting or applying a herbicide after planting will usually reduce grass competition sufficiently for two or more years until seedlings are large enough to compete on their own.

Competition for Light

■ Example: Seedlings overtopped by raspberries

Seedlings may survive, but will be very spindly if they do. These frail seedlings are more susceptible to damage by the elements, especially snow.

Manually cutting the raspberries is extremely difficult and will need to be done each year since the raspberries can resprout after cutting. This is expensive, time consuming work and may only be practical for small plantations. The best method for breaking up dense raspberries in large plantations is chemical weed control, using a registered herbicide.

In Nova Scotia, ground or aerial application of registered herbicides is the most commonly used method of weed control in plantations. It is both economical and effective.

There are presently two types of herbicides registered for forestry use:

1. Root uptake herbicides such as Velpar L (Hexazinone) and Princep Nine-T (Simazine) are most commonly used for weed control before planting. These are applied in early spring when plants begin to grow. They work best if applied just before light rains which moves the herbicide into the soil where it is taken up by the roots.
2. Leaf intake herbicides such as Vision (Glyphosate) are usually applied in late summer (August-September) when softwoods have hardened off and are dormant. Hardwoods and other herbaceous plants are still actively growing and are killed by the application of Vision. This releases the conifers from the overtopping cover of weeds during the next growing season.

Chemical weed control reduces, but does not eliminate, the competition for light and space and gives the planted seedlings room to grow.

Manual weed control is not as effective or as feasible as herbicides since most competing vegetation sprout vigorously after cutting. Manual weeding would likely need to be repeated several times to ensure plantation success. Usually, herbicides need only be applied once during the life of a forest stand (40-80 years depending on length of the rotation).

APPLYING THEORY TO PRACTICE

Finally, let's look at two of the most common stand types that require a regeneration management strategy to guarantee productivity for the next rotation.

1. "Budworm damaged balsam fir and white spruce stands in Cape Breton"

Typical mature and overmature balsam fir and white spruce stands are 30-70 percent dead and have been dead for 4-5 years (in 1989). As these stands break up, light reaches the forest floor to allow establishment of patchy regeneration and weeds. With live trees, dead trees (standing and blowdown), patches of desirable and undesirable regeneration, and bare patches, these stands are a real mess. Well prescribed plantation management strategies for these budworm damaged stand begin by:

(a) Developing a plan before harvesting:

The stand should be divided into two distinct operating areas if possible, based on a pre-harvest stand assessment.

Block 1: Area with satisfactory stocking of desirable regeneration.

Block 2: Area not satisfactorily stocked to desirable regeneration.

Each block needs to be large enough to make the operation economically feasible, 2-4 ha (5-10 ac).

(b) Harvest

- Block 1: Organize felling and wood extraction to minimize damage to existing regeneration. Decide whether crushing the debris by dozer or roller will benefit future thinning operations, without seriously damaging the regeneration.
- Block 2: Organize felling and wood extraction to facilitate efficient site preparation.

(c) Site Preparation

- Block 1: Crush debris if beneficial; if not, leave as is.
- Block 2: Brush rake debris into corridor piles or wait at least one year to use a crushing roller. Leaving slash to rot for 2 years can greatly reduce site preparation costs and result in a better job. If necessary, apply a root uptake herbicide such as Velpar L before planting to control competition.

(d) Planting

Order planting stock six months or more in advance for best selection. Order white spruce, Norway spruce or white pine for sites with well drained soils; red spruce for well drained, sheltered sites (Cape Breton only); and black spruce for sites where drainage tends to be poor. Container or jiffy pot seedlings are preferred for ease of planting; small bareroot stock is second choice; and large bareroot stock should be planted where weed competition is expected to be a problem. Plant at 1.8 m x 1.8 m (6 foot) spacing as soon as the ground thaws in the spring.

(e) Weeding

Assess plantation annually for weed problems. Carry out chemical weed control if seedlings are suffering from competition. Use one application of a leaf absorbed herbicide such as Vision in late August or September to reduce competition. Continue yearly assessments until the average height is 2 m (6 ft) and use chemical or manual weed control as necessary. Plantation is now "free to grow" to age 30-40 years at which point a merchantable thinning may be required.

2. Mature to Overmature "White Spruce Stands"

White spruce stands usually begin to show reduced growth and decline between 40-60 years of age. In Nova Scotia, white spruce stands do not usually regenerate naturally to white spruce with either shelterwood cutting or clearcutting. Therefore, clearcutting and planting are usually recommended in mature to overmature white spruce stands, preferably following these five steps to successful plantation establishment.

(a) Develop a plan before harvesting:

Do a pre-harvest stand assessment. Is desirable regeneration present? Occasionally, white spruce stands regenerate to red spruce, balsam fir, white ash, or sugar maple if a seed source is available. If desirable regeneration is present and the area is sufficient, divide the stand into two operating areas - Block 1 and Block 2 - and follow the previous suggestions on budworm damaged stands.

(b) Harvest

Ensure that the favoured method of harvest is organized to make future operations as efficient and effective as possible. Good wood utilization and minimal site damage will help at the site preparation stage, if necessary.

(c) Site Preparation

- For whole-tree harvest, may not be needed.
- For conventional harvest, rake slash into corridors or let brush rot for 2-3 years, then crush with roller.
- For high risk of seedling debarking weevils, wait at least two years after harvest before planting.
- If necessary, use one application of Velpar L or Vision herbicide to control competition before planting.

(d) Planting

Order trees in advance. Select the best species to match your site. Choose the appropriate stock type unless land classification indicates otherwise.

(e) Weeding

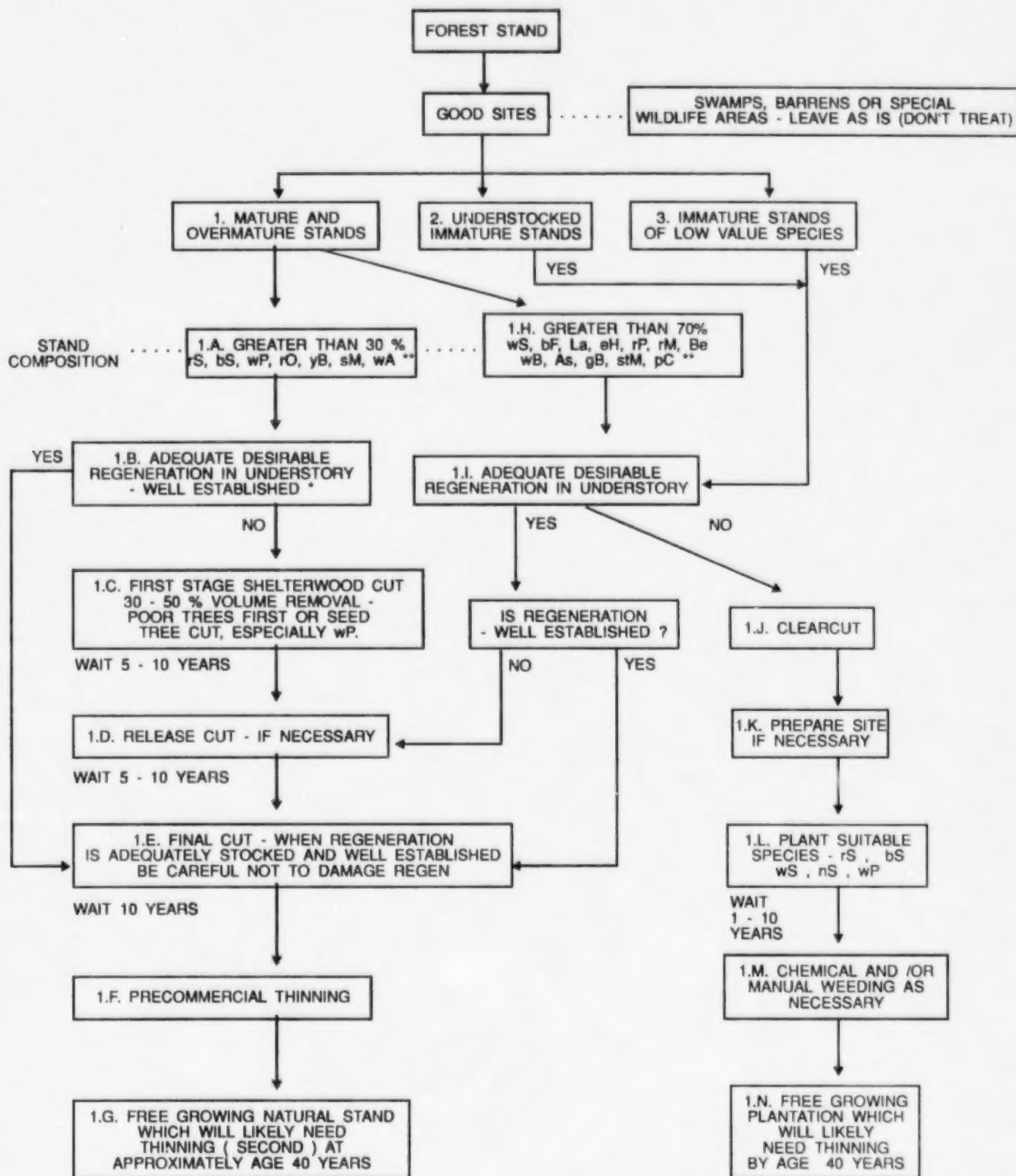
Follow the 1 (e) suggestions for Weeding in budworm damaged stands.

SUMMARY AND REVIEW

Figure 12 will help you decide which stand establishment practices are best suited for your woodlot.

Forests generally grow slowly. It can take 40-60 years for a tree to mature. Stand establishment and development processes that occur on your woodlot will take time to see and understand. Carefully watch and note the effects of cutting and natural succession. Discuss your own particular situation with forestry personnel. You will begin to understand and apply this knowledge to improve the management of your woodlot.

FIGURE 13. DECISION - MAKING FLOWCHART FOR STAND ESTABLISHMENT



* NOTE: WELL ESTABLISHED IS A GENERAL TERM USED TO DESCRIBE REGENERATION THAT IS LARGE ENOUGH TO HAVE OUTGROWN THE COMPETITION FROM WEEDS AND WILL SURVIVE AFTER THE FINAL CUT. A GENERAL GUIDELINE FOR WELL ESTABLISHED SEEDLINGS IS AT LEAST 1 FOOT FOR SOFTWOOD AND 1 1/2 FEET FOR HARDWOOD, BUT IT ALSO DEPENDS ON AVERAGE SEEDLING VIGOUR (PREVIOUS YEARS GROWTH)

QUIZ

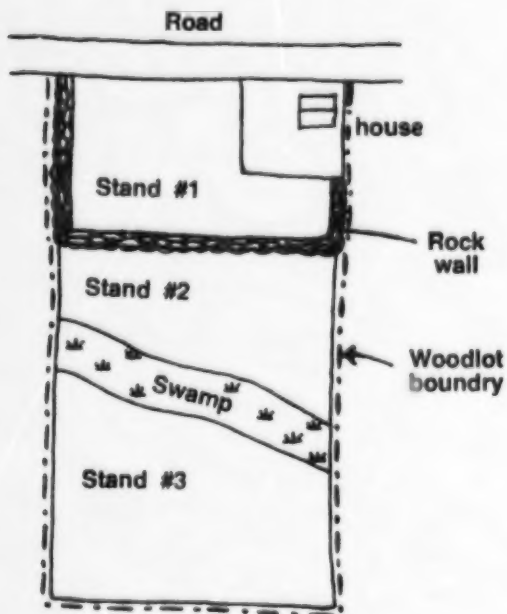
TRUE OR FALSE

- _____ 1. In 1989 approximately 30 million seedlings were planted in Nova Scotia.
- _____ 2. For best results, planning for planting begins after harvest.
- _____ 3. Rabbits prefer nursery stock over natural seedlings for food.
- _____ 4. Nutrient removals resulting from whole-tree logging is a serious concern for forestry experts.
- _____ 5. Grass competition is not a serious problem for red spruce seedlings.
- _____ 6. Black spruce is a preferred species for planting on wet sites.
- _____ 7. Seedlings usually do well when planted on thick duff or rotten wood.
- _____ 8. August through early September is usually a good time to plant in Nova Scotia.
- _____ 9. Manual weeding is more effective than chemical weeding in very young plantations.
- _____ 10. For best conifer release results, leaf uptake herbicides should be applied in early spring.

WOODLOT MANAGEMENT EXERCISE

Let's look at a sample woodlot that has three distinct stand types and determine the site history of each type based on what we know about the strategy for survival for each species. Based on what you have just read and your own experiences, what would be the site history and stand establishment recommendations for the following three stands? Suggested answers are given on the next two pages.

JOHN DOE'S WOODLOT - DOEVILLE STATION, N.S.



Stand 1:

40 year old evenaged stand
90% white spruce; 10% balsam fir,
grey birch

Site History _____

Stand Establishment
Recommendations _____

Stand 2:

20-50 year old unevenaged stand
70% red maple, white birch, beech;
20% balsam fir; 10% red
spruce, yellow birch, sugar maple

Site History _____

Stand Establishment
Recommendations _____

Stand 3:

80 year old evenaged stand
70% red spruce, eastern hemlock; 20%
yellow birch, sugar maple, beech;
10% red maple, white birch

Site History _____

Stand Establishment
Recommendations _____

SUGGESTED ANSWERS

Stand 1

Site History

This stand was likely an abandoned field or pasture that has become a white spruce forest. Signs include the large amount of white spruce that borders the homestead surrounded by rock walls and wire fence. You may want to check the surrounding soil. If it is flat, it may indicate earlier farm cultivation.

Recommendation

Table 3 tells us that white spruce stands generally mature between 40-60 years. This stand is likely mature or nearly mature and should be harvested within the next 20 years as it begins to show signs of decline. White spruce stands usually do not regenerate well even with shelterwood cutting. The forest floor should be assessed for existing natural regeneration before harvesting. The stand will likely need to be planted.

Stand 2

Site History

The unevenaged condition and pioneer species such as white birch and pin cherry indicate that cutting took place in this stand 20-50 years ago. The presence of shade tolerant species like red spruce, yellow birch, sugar maple, and beech shows that the site was probably dominated by these species in the past. Historically, stands closest to the homestead were used for fuelwood. Some pulpwood or logs were also cut each winter for extra cash.

Recommendation

This stand is generally immature and should only be considered for stand establishment if significant areas are either understocked or occupied by low value species. If either of these situations do exist, assess the site for desirable natural regeneration. A release cut can be done if adequate regeneration is present. If regeneration stocking is inadequate, it may be best to clear the site and plant more desirable species. If the stand is adequately stocked with good quality trees, thin the dense areas to favour the desirable species. Otherwise, this stand could be left to grow for 10-20 years then reassessed for stand establishment practices.

Stand 3

Site History

The stand is evenaged and likely resulted from a clearcut. Red spruce, eastern hemlock, sugar maple, yellow birch, and beech advance regeneration were probably present in the original stand. The red maple may have originated as sprouts, but like the white birch, may have seeded in on logging trails or openings. The advance regeneration of the shade tolerant trees may have started in natural openings created in the previous stand as trees died or blew down. This stand was likely saved from harvesting because of the long distance from the road and by the swamp. The stand can give us some insight into what the other two forest stands may have looked like.

Recommendation

As noted in Table 4 of Lesson 1, we see that the white birch, red maple, and beech are likely overmature and are beginning to die. The red spruce, sugar maple, yellow birch, and eastern hemlock are reaching maturity. The site should be assessed for regeneration. If necessary, shelterwood cutting could be started.

TREE SPECIES ABBREVIATIONS

SOFTWOODS

red spruce	- rS
balsam fir	- bF
eastern hemlock	- eH
white spruce	- wS
black spruce	- bS
white pine	- wP
larch (tamarack)	- La
red pine	- rP

HARDWOODS

red maple	- rM
sugar maple	- sM
yellow birch	- yB
white birch	- wB
beech	- Be
aspen (poplar)	- As
red oak	- rO
white ash	- wA
pin cherry	- pC
grey birch	- gB
striped maple	- stM

ANSWERS TO QUIZ QUESTIONS

LESSON ONE:

- | | |
|----------|-----------|
| 1. FALSE | 6. TRUE |
| 2. TRUE | 7. FALSE |
| 3. FALSE | 8. TRUE |
| 4. FALSE | 9. TRUE |
| 5. TRUE | 10. FALSE |

LESSON TWO:

- | | |
|----------|-----------|
| 1. FALSE | 6. TRUE |
| 2. TRUE | 7. FALSE |
| 3. TRUE | 8. FALSE |
| 4. TRUE | 9. TRUE |
| 5. FALSE | 10. FALSE |

LESSON THREE:

- | | |
|----------|-----------|
| 1. TRUE | 6. TRUE |
| 2. FALSE | 7. FALSE |
| 3. TRUE | 8. TRUE |
| 4. TRUE | 9. FALSE |
| 5. FALSE | 10. FALSE |